Report on an Analytic Network Process (ANP) Model to Estimate the Benefits, Opportunities, Costs, and Risks (BOCR) that Gun Policies and Violence Prevention Interventions Have on Legal Users of Firearms

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ABSTRACT

Balancing public good with individual rights is a difficult task; gun policies attempt to do just this. To ensure public safety, local, state, and federal agencies piece together policies that each entity believes will meet the needs of public welfare. When legislating new gun policies, the impact the policies have on gun owners are perceived as a zero-sum game; some groups are perceived to gain while others think they are losing, but the reality is much more nuanced.

The reason the impact of these policies on all lawful gun owners has been considered a zero-sum game is largely because to date there has been no research measuring the impact. Further, there have been no attempts to quantify the impact that the policies have on lawful gun owners. The sole argument that has been made is about constitutionality.

In this paper, we develop an approach based on the Analytic Hierarchy Process (AHP). The approach allows us to develop criteria for evaluating the impact of these policies on lawful gun owners and generate priorities for the criteria from pairwise comparisons. Criteria are compared in pairs, thus the term pairwise comparisons. This allows us to score, as with a scorecard model, gun policies for various types of gun owners with respect to the criteria according to the Benefits, Opportunities, Costs, and Risks, thereby determining the impact of each policy.

We show how relative measurements are derived and illustrate with an example how ratings (absolute measurement) work in the context of an organ donor model. Next, we

develop a gun policy model hierarchy to show how the approach might be structured. A hypothetical gun policy – a single shot only policy – is evaluated against the model for various types of lawful gun owners to illustrate the approach. Since the model will need to be tested with a large group of stakeholders, we discuss how to develop the priorities from large groups. Finally, we discuss how this approach might be implemented.

This work may be of interest to policy makers at the federal, state, and local levels since gun control policy happens at every level of governance in the United States. Additionally, this work may be of interest to lawful gun owners who may wish to apply the approach to their own context to see how they may be personally impacted by a given gun control policy. Finally, researchers may find this research of interest because the approach is applicable in other contexts and presents a novel way to consider the impacts of policy decisions.

Keywords: gun laws; Benefits; Opportunities; Costs and Risks; Analytic Hierarchy Process

1. Introduction

This paper is not about the gun debate in America, but about how gun control policies impact legal gun owners. In the process of developing a model to measure the impact of gun control policies, we need to introduce a theory based on relative measurement. Relative measurement is used when there are no scales to measure certain attributes known as intangibles. An intangible is an attribute that cannot be measured with a scale common to all members of a society, for example, love. There is no common scale to represent how much you love a person. However, everyone has an idea of the intensity of their love for other people. On the other hand, a tangible attribute is one that society measures using a commonly agreed upon tool. For example, temperature, distance, and weight, are measurable using a scale that society has agreed to use, but even when different societies use different scales, the results can be compared depending on the type of scale used.

The impacts of gun control policies are not just monetary for some users, but also include intangibles, like not being able to enjoy hunting, or target shooting, or being afraid if they do not have a way to defend themselves. We are not only trying to understand how gun control policies impact legal gun owners, but also which type of gun owner is most affected. There are not many statistics about how existing laws impact behavior, let alone how they impact people's lives. However, we believe that society as a whole has an idea about how those laws impact and influence what we do from day to day. So, why do we want to measure the impact gun policies have on legal gun owners? Perhaps we want to make sure that we allocate resources more efficiently when developing gun control policies. For example, in countries where citizens are not allowed to have any type of gun, there may not be a need for a background check policy. This is not the case in the United States.

Studying the impact that a law has on the society in which it is applied helps to better understand the balance that exists between advantages and disadvantages the law creates. (Forji, 2010) writes:

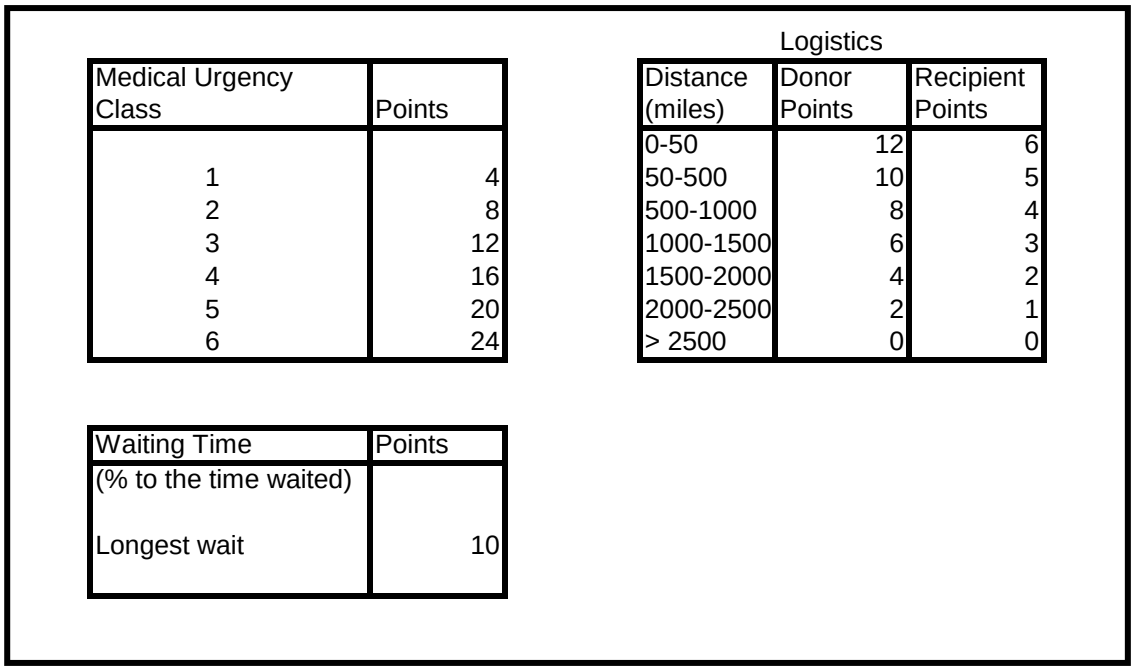
> "It is in the interest of the legal order that it strive for genuine justice in order to dissuade individuals from inducements to *contra bonos mores*. When from a particular conduct, the benefits or advantages are more than the disadvantages or sufferings to an individual; that individual can certainly be expected to opt for compliance, because the benefits (pleasures) of compliance outweigh the disadvantages (pains) of violation. The reverse conduct would be true for a legal system which is prone to injustice, hardship and sufferings to some or most of its subjects, given that the latter beside their pains are not giving any motivation to abide to the legal order. In this case, the advantages of violation seem just as good if not better as of compliance (p. 86)."

This paper is not addressing the issue of what law helps prevent more suicides, mass murders or domestic violence. Perhaps, that could be the subject of another paper. Here, we are interested in measuring the impact of gun control policies on people who legally own a gun. Because the impacts of these gun policies involve intangibles, we need to use relative measurement (see Appendix A). The example that follows shows how to use ratings (scorecard) to develop an ordered list of potential recipients of a cadaver liver from a donor.

2. Example of how Absolute Measurement (or ratings) works

Cook et al. (1990) proposed the use of an AHP model to develop a rating system using absolute measurement for the allocation of cadaver livers for orthotopic transplantation. Five major criteria for comparison were established, defined, and rated relative to one another. They were logistic considerations, tissue compatibility, waiting time, financial considerations, and medical status. Subcriteria were also established and prioritized in relative terms (see Figure 2). Patients that met appropriate inclusion screening criteria were rated according to the scales in Figure 3. The final weighting can be used to develop an alternative to the rigid computerized multifactorial point system that existed at the time of the publication (see Figure 1).

In Figure 4, the existing list in 1990 showed that patient #6 was the desired choice with a score of 39.76 points. This score was obtained by assigning points to the patient according to the scales in Figure 3. The donor points −8 − can be seen in the upper right-hand corner of Figure 6 next to the word Logistics. Using Cook et al.'s system, the list of patients given in Figure 4 were also scored (or rated). The patient that was selected for the transplant is now in the 7th position (see Figure 5). Clearly, both systems do not provide the same rankings. How does one decide which one is more acceptable? Some criteria to consider would be accountability, clarity of weight assignment and capability to explain how the weights were derived.



Medical Urgency Class	Points
1	4
2	8
3	12
4	16
5	20
6	24

Logistics

Distance (miles)	Donor Points	Recipient Points
0-50	12	6
50-500	10	5
500-1000	8	4
1000-1500	6	3
1500-2000	4	2
2000-2500	2	1
> 2500	0	0

Waiting Time	Points
(% to the time waited)	
Longest wait	10

Figure 1 Scoring system for liver assignment in 1990

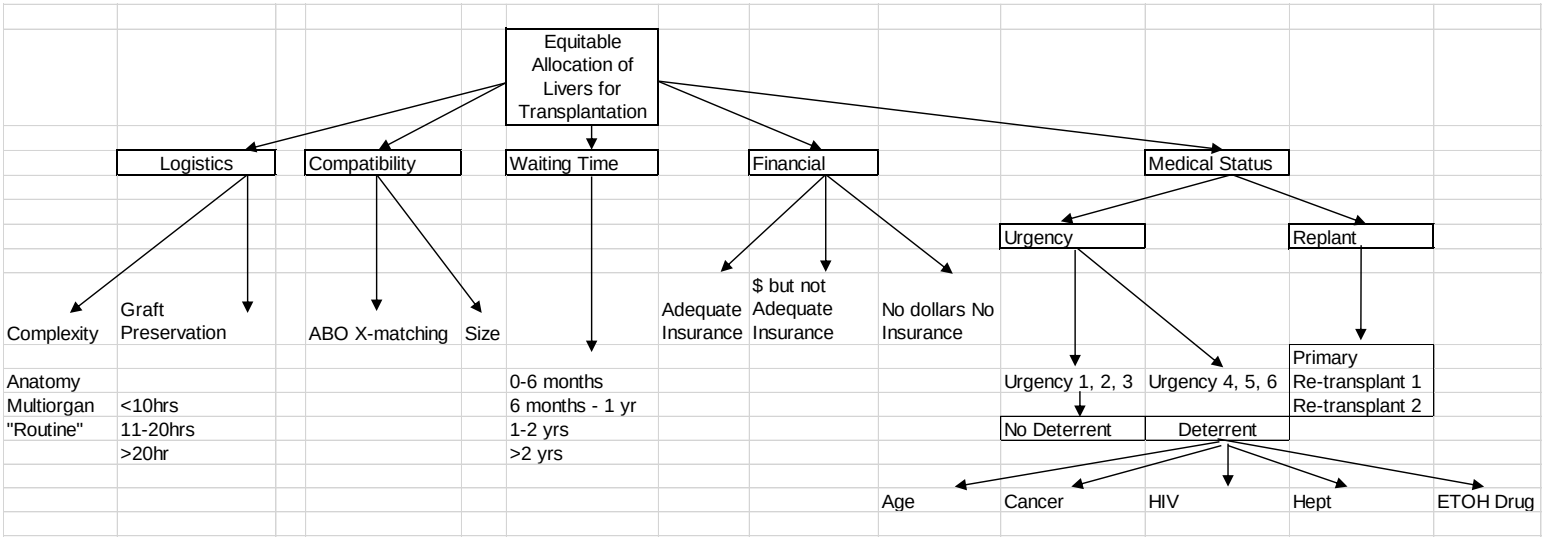


Figure 2 Equitable allocation of livers for transplantation

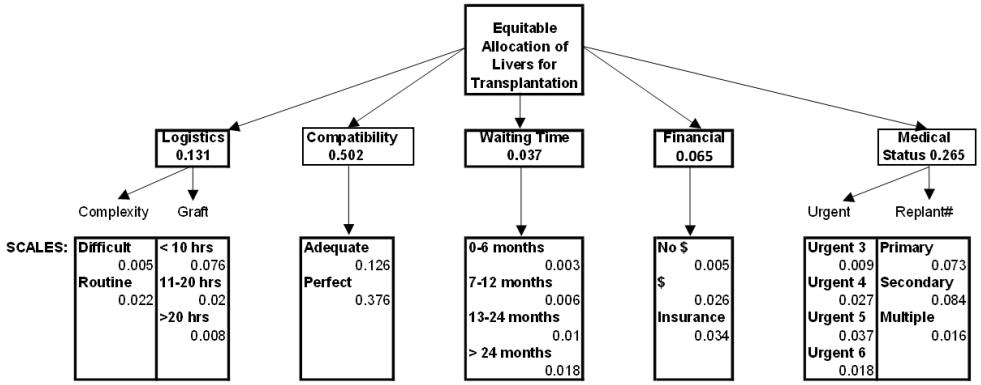


Figure 3 Priorities of criteria, subcriteria and rating scales

Table 3
UMY – Transplant Information Management System Liver Registry – Adult scoring system

Donor data – ABO 01 – Type O Liver vol. Height 5'6"-(173cm) Weight 178lbs (80.63kgs) Age 20.0 Sex 01 – Male Logistics 8

Name	ABO	Liver vol.	WT	HT	Diagnosis/Remarks	Days wait	% Wait	ABO	Urgency	Logistics	Total score
1	O	676	157 lb 71.1 kg	5'8" 173 cm	CRYP CIR OLDX	32	0.26	10	16	5	32.26
2	O	1200	177 lb 80.2 kg	5'9" 175 cm	CAH HBsAg+ UM HERNIA	4	0.03	10	16	6	32.03
3	O	1038	125 lb 56.6 kg	5'2" 157 cm	CIX RESECTION 1996	3	8.02	10	16	6	32.02
4	O	1828	110 lb 49.8 kg	5'2" 157 cm	SC, UC R-Y LOOP GAC, CBD RE-EX	738	5.91	10	12	4	31.91
5	A	1031	198 lb 89.7 kg	5'6" 158 cm	HEMACHROMATOSIS SPLENECTOMY	11	0.09	5	20	6	31.09
6	O	1125	122 lb 55.3 kg	5'3" 160 cm	SC OX, SR SHUNT, BLEED X 2.9?	1094	6.76	10	9	4	39.76
7	O	1407	176 lb 79.7 kg	6'1" 185 cm	CAH, UC NONE	501	4.01	10	12	4	30.01
8	O	1209	140 lb 63.4 kg	5'7" 170 cm	SC HEPL, SPLX	304	2.43	10	12	5	29.43
9	O	1006	133 lb 60.2 kg	5'8" 173 cm	CIR TAH	74	0.59	10	12	6	26.59
0	A	1397	180 lb 81.5 kg	5'10" 178 cm	SC/UC NONE	1236	9.90	5	8	5	27.90
1	B		160 lb 72.5 kg	5'8" 173 cm	CAH-HBsAg, VIRAL APPY	53	0.42	5	16	6	27.42
2	A	1518	146 lb 66.1 kg	5'8" 173 cm	SC OX, WARREN SHUNT, FEED GAST	25	0.20	5	16	6	27.20

Figure 4 Example of a liver donor and an ordered list of potential recipients

Alternative	Total		Logistic|Cor	Logistic|Graft Preservation|(	Compatibility|(	Waiting Time|(U	Financial|(U	Medical Status|Urgent|(	Medical Status|Replant|(
Patient 2	0.092		Routine	<10hrs	Perfect	0-6 months	Insurance	#4	Primary
Patient 3	0.082		Routine	<10hrs	Perfect	0-6 months	No $	#3	Primary
Patient 7	0.074		Routine	11-20hrs	Perfect	13-24 months	Insurance	#3	Primary
Patient 8	0.072		Routine	11-20hrs	Perfect	7-12 months	Insurance	#3	Primary
Patient A	0.071		Routine	11-20hrs	Perfect	0-6 months	Insurance	#3	Primary
Patient 4	0.07		Difficult	11-20hrs	Perfect	>24 months	No $	#3	Primary
Patient 6	0.07		Difficult	>20hrs	Perfect	>24 months	$	#3	Primary
Patient 9	0.07		Routine	11-20hrs	Perfect	0-6 months	$	#3	Primary
Patient 1	0.068		Routine	>20hrs	Perfect	0-6 months	Insurance	#3	Primary
Patient C	0.053		Routine	11-20hrs	Adequate	13-24 months	$	#5	Secondary
Patient 5	0.051		Routine	11-20hrs	Adequate	0-6 months	Insurance	#5	Primary
Patient B	0.049		Routine	11-20hrs	Adequate	7-12 months	$	#4	Secondary
Patient 11	0.048		Routine	11-20hrs	Adequate	0-6 months	Insurance	#4	Primary
Patient 10	0.045		Routine	11-20hrs	Adequate	>24 months	$	#3	Primary
Patient 12	0.043		Difficult	>20hrs	Adequate	0-6 months	Insurance	#4	Primary
Patient D	0.042		Difficult	11-20hrs	Adequate	7-12 months	No $	#4	Primary

*Numbers in the column Total do not add to 1 because of rounding off error.

Figure 5 Final ordered list of patients from Figure 4 obtained using the proposed AHP model

3. Hierarchy of impacts of gun control policies

We propose building a similar system as illustrated in the liver donor model to evaluate the effects of gun control policies on lawful owners of firearms. The difference resides with considering not just benefits and costs, but the uncertainty in benefits, that we call opportunities, and the uncertainty within costs, termed risks.

The goal of the model is to measure the impact that gun control policies have on legal gun owners. Thus, if we model it as a hierarchy we would have the following:

1. **Goal**: Measure the impact of a gun control policy on lawful gun owners.
2. **Strategic Criteria**:
   At the macro-level, gun control policies have an impact on society as a whole. When considering the enactment of gun control policies, policymakers need to consider strategic issues. The political, economic, social, technological environmental, and legal (PESTEL) framework is commonly used to capture the macro-environment when making strategic decisions.
   a. **Political impact**: these impacts may include things like the pressure that is being placed on legislators to enact or repeal gun laws; the importance that gun control measures play in an election cycle; the donations being made by lobbying groups; etc.
   b. **Economic impact**: these impacts may be seen in the growth or contraction around the gun industry related to gun manufacturing. For instance, the IMPLAN[1] application has industry code 257, "small arms, ordnance, and accessories manufacturing," employing 20,768 people with $1.6M in labor income. Gun control laws that impact this industry may have an economic impact through direct, induced, and spillover effects.
   c. **Social impact**: when considering the impact that a gun policy has, social issues need to be considered as well. For instance, there are matters of public good, safety, and health that may be impacted.
   d. **Technological impact**: research and development, among other technological areas, may be impacted by gun control policies.
   e. **Environmental impact**: the manufacturing, use, and disposal of guns, accessories, and material may have an environmental impact. Hence, consideration of the environment needs to be taken.
   f. **Legal impact**: the legal framework needs to be considered since gun control policies may be affected by existing laws and statutes.
3. **Benefits, Opportunities, Costs, and Risks**
4. **Intensity Scales for each of the Benefits, Opportunities, Costs, and Risks.**

[1] Economic Impact Analysis for Planning – https://www.implan.com

The proposed hierarchy is illustrated in Figure 6.

It is common sense to assume that not all gun owners think the same about the impact of gun control policies. Thus, the strategic criteria need to be prioritized according to different types of gun owners, including[2]:

a. Recreational

i. Hunters – there are a variety of types of hunters. For instance, a bird hunter might prefer a shotgun, whereas a deer hunter might prefer a cartridge. There are some hunters that prefer black-powder, whereas others may prefer high-power. Some hunters hunt for recreation, whereas others hunt to supplement their food. We do not separate the various types of hunters, but recognize there is a variety.

ii. Shooting – paper fixed targets, skeet, and pop-up.

iii. Enthusiasts – these are generally people who feel an affinity to guns.

iv. Collectors – this category of gun owner tends to possess them for the potential appreciation in value. They may display their guns and could have many in their possession.

v. Historical reenactment – this category may have weapons for recreating battles such as Gettysburg, may participate in demonstrations such as Veteran's Day parades, or take part in filming.

b. Protectionists

i. Private security guards – these individuals are typically contracted out through a firm to cover banks, buildings, and other locations. They may be required to own their own gun, though their employer may provide one.

ii. Private citizens – homeowners, personal protection, automobile.

iii. Law enforcement – these individuals will often be issued a service weapon, but may also have personal weapons that they may decide to carry while working and may also carry while off-duty.

iv. Retired and active duty military – military members may have basic weapons training, but may also have advanced weapons training. These individuals may have a variety of types of weapons.

c. Gun shop owners - Dealers

d. **Survivalists** – these individuals may purchase weapons with the idea of needing them should social structures and services fall into disarray.

[2] These categories are not mutually exclusive, and a gun owner might fall into multiple categories. It is important to distinguish the categories since a gun policy may affect one type of gun owner more than another.

e. **Paramilitary** – these individuals may possess weapons for the purpose of serving in a militaristic type of organization which is not government backed or supported.

The selection of the types of gun owners is based, in part, on a review of the literature for what lawful gun ownership looks like ((Moore, 1983).

To develop priorities for each group, we needed to compare the strategic criteria according to their perceived importance for each group. For example, for a given group, given two criteria, e.g., political and economic, which one is more important when considering a gun control policy, and how much more important? These pairwise comparisons of the criteria are then used to derive priorities that different groups assign to the different dimensions of a gun control policy.

Next, we needed to identify the impacts of each specific gun control policy. Any gun control policy has several favorable and unfavorable aspects to consider. Some of these are certain, others are less so and only likely to materialize. The favorable concerns that are certain are called **Benefits (B)** while the unfavorable ones are called **Costs (C)**. The uncertain concerns of a decision that are positive are characterized as **Opportunities (O)** that the decision might create and the negative as **Risks (R)**. These concerns can have monetary and non-monetary implications. Thus, intangible attributes are at the heart of the measurement of the impacts of a gun control policy on legal owners of guns. The specific impacts of a gun control policy need to be evaluated in terms of the concerns (e.g., benefits), and each of the concerns is measured on its own scale. For example, assume that gun control policies impact the benefit of protection with different intensity that can range from none (i.e., no protection) to very high (i.e., very high protection). The scale for each intangible impact needs to be developed using pairwise comparisons. Let us assume we want to construct the intensity scale for the protection benefit. The following matrix shows an example of the pairwise comparisons obtained in response to the following question: "Given two intensity levels, e.g., none and low, how much more intense (important) is low than none using the fundamental scale from Table 1 in Appendix A."

	1	2	3	4	5	Priorities	Ideal
1. None	1	1/3	1/5	1/7	1/9	0.033	0.06
2. Low	3	1	1/3	1/5	1/7	0.063	0.12
3. Medium	5	3	1	1/3	1/5	0.129	0.25
4. High	7	5	3	1	1/3	0.261	0.51
5. Very High	9	7	5	3	1	0.513	1

The values under the word "Priorities", in the table above, are the relative intensities of the Benefit Protection rating scale. Sometimes, it is more convenient to use the ideal form which is obtained by dividing each relative priority by the largest value. In this example,

each priority is divided by 0.513. This will be done for each impact in the concerns identified under benefits, opportunities, costs, and risks. These scales will have to be constructed individually for benefits, opportunities, costs, and risks because the intensity of the scale's levels depends on the dimension for which they will be used. For example, the pain of a loss or cost is usually perceived to be greater than the pleasure of an equal gain or benefit. Thus, the scales will have to reflect these perceptions (Kahneman & Tversky, 1979).

Benefits[3]:

a. Security and Peace of Mind – the ability of the gun owner to derive a sense of calmness from knowing that she/he owns a weapon that is available for use should the need arise. The sense of security and peace of mind derives from several sub-criteria:
    1. Protection – under protection, a lawful owner views the gun as an instrument of protection. The protection may be for oneself, one's family or perhaps property. The scale used to rate potential policies or laws ranges from "provide no protection" to "provides a lot of support for protection or "very high".
    2. Respect – under this criterion, the gun owner may possess the weapon out of a sense of *esteem* derived from the perception that others see the owner as possessing some 'power'. The scale used to rate the policy or law ranges from "none, it provides no support for a sense of respect" to "very high, the policy supports the owner's sense of respect."
    3. Posturing – this criterion derives from a recognition that there are some gun owners who may possess the weapon in order to present a certain pretense. Gun policies and laws may diminish or support the ability of the lawful gun owner to present this pretense. Like protection and respect, the scale used to evaluate the policy ranges from none to very high.
b. Psychological – the security and peace of mind cluster largely constitutes external considerations. This cluster derives from internal positive feelings in this case. The difference between this cluster and the security and peace of mind cluster is subtle, but we estimated that the source of the benefit is derived from differing motivations. It is comprised of the following sub-criteria:
    1. Self-esteem – this is a measure of how the lawful gun owner feels about him or herself because of the fact that he or she can own a gun. The scale ranges from none to very high.
    2. Identity – this is a measure of the degree to which gun ownership is integral to how the owner identifies him or herself. The scale ranges from none to very high.

[3] Here we consider direct, known gains that the lawful gun owner receives.

3. Turf – here, we capture the idea that one might own a gun with the intent of defending one's territory or have the means to defend one's territory if necessary. This is different from self-defense or protection where the owner is concerned about his or her home.
4. Community (belonging) – there are some gun owners who possess the gun because they feel a sense of belonging with others. The act of ownership facilitates the inclusion into a group that is larger than just the individual, e.g., being part of the National Rifle Association or a local hunting club.

c. Recreation – this category of lawful gun owners possess guns primarily for recreational purposes or enjoyment.
    1. Hunting – these are lawful gun owners whose primary reason for gun ownership is for hunting purposes (fowl, deer, etc.).
    2. Ornamental – gun ownership for the purpose of display.
    3. Stress Release – gun ownership for the purpose of releasing tension.
    4. Target shooting – these gun owners enjoy shooting at targets (paper, pop-up, clay, etc.). The target shooters are more competitive than those that shoot for stress release and may participate in competitions.
d. Constitutional right – this category of individuals tends to possess guns because they consider it a constitutional right. The possession of the weapon is an act of maintaining the right itself.
    1. Freedom – these types of gun owners possess weapons as an expression of independence.
    2. Militia – these gun owners possess weapons as an act of upholding the Second Amendment imperative to maintain "a well-regulated militia."
    3. Bear arms - these gun owners possess weapons as an act of upholding the Second Amendment right to "bear arms."

Opportunities[4]:

a. Insurance – this is largely a measure of an individual wanting to keep a gun for safety in case something should happen.
b. Appreciation – some gun owners hold their guns for an investment.
c. Identity – these gun owners feel that the gun is a function of their identity and without it may lose some sense of self.

Costs[5]:

a. Economic – these include the fiscal costs associated with the implementation of a gun control policy.
    1. Purchase Price – defined as the initial purchase costs associated with the gun or related matter need for the ownership of the gun.

[4] Potentialities, things that the gun owner may get at some time in the future.
[5] Direct cost of lawful gun ownership.

2. Operational – the ongoing costs of maintaining the ownership of the gun.
3. License – the monetary costs associated with legally owning the gun.
4. Insurance – the costs associated with indemnifying the gun owner against potential claims.

b. Social costs – the costs that society may incur from the implementation of the policy, such as lives lost, injuries, and so on.
c. Time – the amount of time spent maintaining legal ownership that may result from applying for a license, waiting, etc.
d. Holding – costs associated with maintaining required storage of the gun associated with policies.
e. Reporting – costs associated with reporting requirements that may be imposed by the gun policy.

Risks[6]:

a. Safety – the risk to the environment (i.e., damage to personal property).
b. Bodily harm – the injury to oneself or others.
c. Noncompliance – the ability to maintain legal ownership status as policies change.
d. Identity – the risk that one may lose some sense of self through the implementation of a particular policy or policies.
e. Constitutionality – the risk that a policy may be perceived as counter to the intent of the Constitution.
f. Restrictions – defined as the extent to which the lawful gun owner may perceive that the policy places additional or undue restrictions on the owner.
g. Liability – the perception that the policy places additional liability on the gun owner.
h. Surrender – the extent to which the gun owner perceives that she or he may be required to surrender personal property.
i. Intrusion - the extent to which the policy is perceived as an imposition in the life of the gun owner.

It is important to understand the relative priorities that gun owners place on the criteria to determine the impact that a gun policy has. In a 2019 study, the Pew Research Center[7] found that 67% of gun owners state that protection is the number one reason why they own guns, 38% claim ownership for hunting, 30% for sport shooting, 13% for gun collecting, and 8% for their work. While it may be true that the gun owner's primary reason for owning a gun is protection, this does not mean that they do not use it for sport

[6] The future, potential negative impacts of lawful gun ownership.
[7] Pew Research Center (2019), "7 facts about guns in the U.S." https://www.pewresearch.org/fact-tank/2019/10/22/facts-about-guns-in-united-states/

shooting or work. Hence, by capturing the relative priorities, we are able to get a more nuanced view of gun ownership and establish a more accurate impact score.

Figure 6 is a graphic representation of the sample hierarchy developed here. The details of the various clusters inside each of the boxes are presented in Table 3 along with the intensity scales. Table 4 gives the priorities derived for the strategic criteria and the benefits, opportunities, costs, and risks. We derived these priorities to illustrate how the framework can be used to evaluate the impact of specific gun control policies on different groups of legal owners of firearms.

To obtain the impact of a gun control policy in terms of, e.g., benefits, we multiplied for each benefit, e.g., protection, its priority (0.0555) by the numeric value of the intensity level with which that benefit is perceived, e.g., none (0.065), and summed across all the benefits. The same was done for opportunities, costs, and risks. The resulting values were combined using the formula:

$$\frac{Benefits\ (B)\times Opportunities\ (O)}{Costs\ (C)\times Risks(R)}.$$

We illustrate its applicability with a fictitious gun control policy we invented for this purpose that we call the "single shot" law.

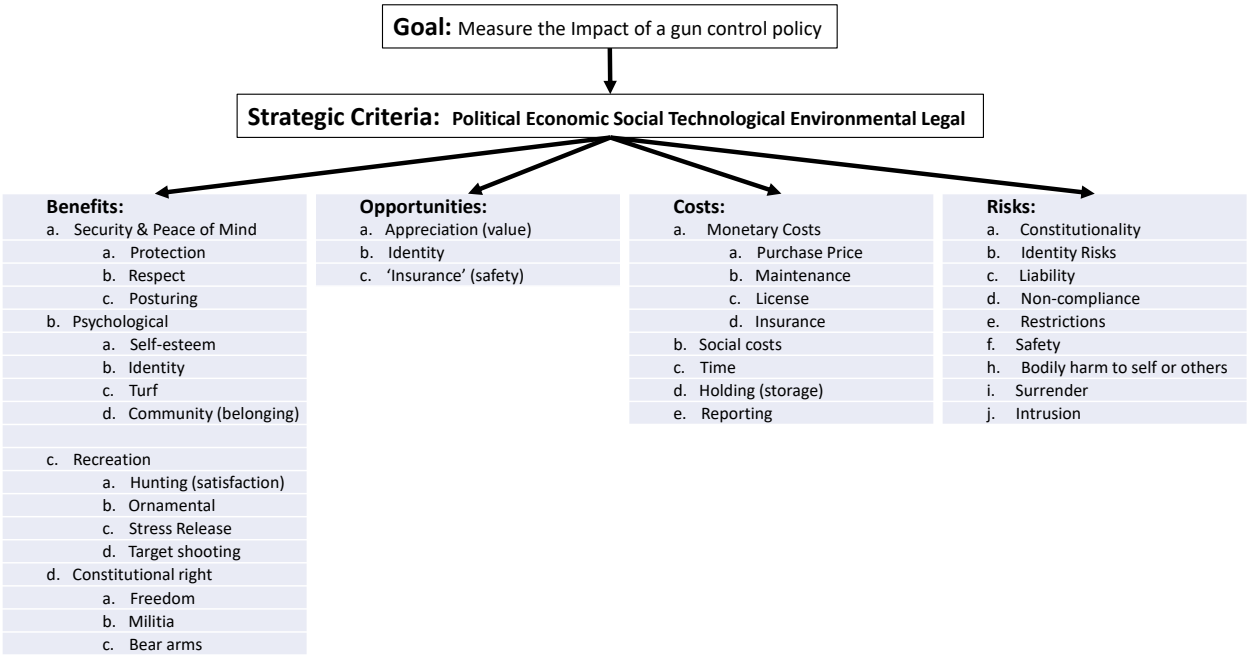


Figure 6 Hierarchy to measure the impact of gun control policy

4. Illustrative example

For illustrative purposes, we developed an example case wherein we simulated an 'expert' opinion to develop the priorities of the strategic criteria and the Benefits, Opportunities, Costs, and Risks (BOCR) model.

The choice of a fictitious policy was intentional to avoid any prior bias of the policy that reviewers may have. The policy that we chose to evaluate was a "Single Shot" law. The "Single Shot" law would make it such that all lawful gun ownership would be limited to firearms that were capable of only a single shot at a time. The single shot policy would make it illegal to own semiautomatic weapons of any kind. A revolver, rifle, or other types of firearms would need a limiting device that would prohibit the use of semiautomatic firing.

Next, we took the position of the four types of stakeholders, the anti-gun person, the collector, the law officer, and the protectionist and rated the policy with respect to each of the criteria to develop the overall score for the policy. The total scores are reported in Tables 5-8. In Table 3, we demonstrate how the intensity scales for each element were prioritized. Following Table 3, we included sample scoring sheets for a 'blank' scoring where we intentionally produced a score of "1" to illustrate the method (Table 4). Following the 'blank', in Table 5, we included a scoring of a hypothesized individual who is against gun ownership followed by the perspective of a collector (Table 6), a police officer (Table 7), and someone who owns a gun for protection (Table 8).

Table 3
Intensity scales

Gun Control Policy:

	Evaluation Scales				
Benefits[1]:					
a. Security & Peace of Mind					
a. Protection	None	Low	Medium	High	Very High
b. Respect	None	Low	Medium	High	Very High
c. Posturing	None	Low	Medium	High	Very High
b. Psychological					
a. Self-esteem	None	Low	Medium	High	Very High
b. Identity	None	Low	Medium	High	Very High
c. *Turf*	None	Low	Medium	High	Very High
d. Community (belonging)	None	Low	Medium	High	Very High
c. Recreation					
a. Hunting (satisfaction)	Absent	Weak	Moderate	Strong	Very Strong
b. Ornamental	No Value	Low Value	Moderate	Strong	Very Strong
c. Stress Release	None	Low	Medium	High	Very High
d. Target shooting	Not Allowed	Controlled	Strictly Controlled	Limited	Allowed
d. Constitutional right					
a. Freedom	No Support	Low Support	Moderate	Strong	Very Strong
b. Militia	No Support	Low Support	Moderate	Strong	Very Strong
c. Bear arms	No Support	Low Support	Moderate	Strong	Very Strong
Opportunities[2]:					
a. Appreciation (value)	None	Low	Medium	High	Very High
b. Identity	None	Low	Medium	High	Very High
c. 'Insurance' (safety)	None	Low	Medium	High	Very High
Costs[3]:					
a. Monetary Costs					
a. Purchase Price	No Impact	Limited	Moderate	High	Prohibited
b. Maintenance	Low	Moderate	High	Very high	Extreme
c. License	Low	Moderate	High	Very high	Extreme
d. Insurance	Low	Moderate	High	Very high	Extreme
b. Social costs	No Injuries	Minor Injuries	Substantial Injuries (full recovery)	Substantial Injuries (partial recovery)	Deaths
c. Time	No Effort	Simple Paperwork	Paperwork with waiting period	Multiple Forms	Substantial Time Investment
d. Holding (storage)	No Requirement	Simple requirement (e.g. lockbox)	Complex Requirement (e.g. safe)	Heavy Requirement (e.g. weapon and ammunition separation)	Extreme (everything under lock and separation
e. Reporting	No Effort	Simple Paperwork	Paperwork with waiting period	Multiple Forms	Substantial Time Investment
Risks[4]:					
a. Constitutionality	In Line with 2nd Amendment	Some Limitations	Moderate Limitations	High Limitations	No Weapons for Civilians
b. Identity Risks	None	Low	Medium	High	Very High
c. Liability	None	Some	Moderate Class Restrictions & Accessories	Highly Liable	Fully Liable
d. Non-compliance	None	Low	Medium	High	Full
e. Restrictions	None	Limited (e.g. class 3)	Moderate Class Restrictions & Accessories	Significant Restrictions	Extreme Restrictions
f. Safety	None	Prevent Adult from Misuse	Prevent Child from Misuse	Prevent Domestic Abuse	Mayhem
h. Bodily harm to self or others	No Injuries	Minor Injuries	Substantial Injuries (full recovery)	Substantial Injuries (partial recovery)	Deaths
i. Surrender	None	Low	Medium	High	Very High
j. Intrusion	None	Low	Medium	High	Very High

[1] Here we consider direct, known gains that the lawful gun owner receives.
[2] Potentialities, things that the gun owner may get at some time in the future.
[3] Direct cost of lawful gun ownership.
[4] The future, potential negative impacts of lawful gun ownership.

Table 4
Priorities of Benefits, Opportunities, Costs, and Risks

Gun Control Policy: **Single Shot Policy**

				Totals	**BO/CR**
Benefits[1]:	Weights	Ratings Labels	Ratings Numeric	**Benefits (B)**	**1.0000**
a. Security & Peace of Mind				**0.0650**	
a. Protection	0.0555	None	0.0650		
b. Respect	0.0555	None	0.0650		
c. *Posturing*	0.0555	None	0.0650		
b. Psychological					
a. Self-esteem	0.0308	None	0.0650		
b. Identity	0.0953	None	0.0650		
c. *Turf*	0.0150	None	0.0650		
d. Community (belonging)	0.0473	None	0.0650		
c. Recreation					
a. Hunting (satisfaction)	0.0214	Absent	0.0650		
b. Ornamental	0.1068	No Value	0.0650		
c. Stress Release	0.1068	None	0.0650		
d. Target shooting	0.1068	Not Allowed	0.0650		
d. Constitutional right					
a. Freedom	0.2169	No Support	0.0650		
b. Militia	0.0434	No Support	0.0650		
c. Bear arms	0.0434	No Support	0.0650		
				Opportunities (O)	
Opportunities[2]:	Weights			**0.0650**	
a. Appreciation (value)	0.4933	None	0.0650		
b. Identity	0.2568	None	0.0650		
c. 'Insurance' (safety)	0.2499	None	0.0650		
				Costs (C)	
Costs[3]:	Weights			**0.0650**	
a. Monetary Costs					
a. Purchase Price	0.0489	No impact	0.0650		
b. Maintenance	0.0098	Low	0.0650		
c. License	0.0219	Low	0.0650		
d. Insurance	0.1093	Low	0.0650		
b. Social costs	0.5134	No Injuries	0.0650		
c. Time	0.1161	No Effort	0.0650		
d. Holding (storage)	0.0881	No requirement	0.0650		
e. Reporting	0.0926	No Effort	0.0650		
				Risks (R)	
Risks[4]:	Weights			**0.0650**	
a. Constitutionality	0.3924	In Line with the 2nd Amendment	0.0650		
b. Identity Risks	0.0207	None	0.0650		
c. Liability	0.0266	None	0.0650		
d. Non-compliance	0.1329	None	0.0650		
e. Restrictions	0.0251	None	0.0650		
f. Safety	0.1492	None	0.0650		
h. Bodily harm to self or others	0.0717	No Injuries	0.0650		
i. Surrender	0.1254	None	0.0650		
j. Intrusion	0.0561	None	0.0650		

[1] Here we consider direct, known gains that the lawful gun owner receives.
[2] Potentialities, things that the gun owner may get at some time in the future.
[3] Direct cost of lawful gun ownership.
[4] The future, potential negative impacts of lawful gun ownership.

Table 5
Anti-gun perspective

Gun Control Policy: **Single Shot Policy**

				Totals	**BO/CR**
Benefits[1]:	Weights	Ratings Labels	Ratings Numeric	**Benefits (B)**	**0.9494**
				0.2934	
a. Security & Peace of Mind					
a. Protection	0.0555	Very High	1.0000		
b. Respect	0.0555	Very High	1.0000		
c. Posturing	0.0555	Very High	1.0000		
b. Psychological					
a. Self-esteem	0.0308	Low	0.1236		
b. Identity	0.0953	Medium	0.2515		
c. *Turf*	0.0150	High	0.5099		
d. Community (belonging)	0.0473	High	0.5099		
c. Recreation					
a. Hunting (satisfaction)	0.0214	Absent	0.0650		
b. Ornamental	0.1068	No Value	0.0650		
c. Stress Release	0.1068	Low	0.1236		
d. Target shooting	0.1068	Not Allowed	0.0650		
d. Constitutional right					
a. Freedom	0.2169	No Support	0.0650		
b. Militia	0.0434	No Support	0.0650		
c. Bear arms	0.0434	Strong	0.5099		
				Opportunities (O)	
				0.0800	
Opportunities[2]:	Weights				
a. Appreciation (value)	0.4933	None	0.0650		
b. Identity	0.2568	Low	0.1236		
c. 'Insurance' (safety)	0.2499	None	0.0650		
				Costs (C)	
				0.0944	
Costs[3]:	Weights				
a. Monetary Costs					
a. Purchase Price	0.0489	No impact	0.0650		
b. Maintenance	0.0098	Moderate	0.1236		
c. License	0.0219	Low	0.0650		
d. Insurance	0.1093	Moderate	0.1236		
b. Social costs	0.5134	No Injuries	0.0650		
c. Time	0.1161	No Effort	0.0650		
d. Holding (storage)	0.0881	Simple requirement (e.g., lockbox)	0.1236		
e. Reporting	0.0926	Paperwork with a waiting period	0.2515		
				Risks (R)	
				0.2621	
Risks[4]:	Weights				
a. Constitutionality	0.3924	Moderate Limitations	0.2515		
b. Identity Risks	0.0207	High	0.5099		
c. Liability	0.0266	Some	0.1236		
d. Non-compliance	0.1329	Low	0.1236		
e. Restrictions	0.0251	Extreme restrictions	1.0000		
f. Safety	0.1492	Prevent adult misuse	0.1236		
h. Bodily harm to self or others	0.0717	Substantial injuries (full recovery)	0.2515		
i. Surrender	0.1254	Low	0.1236		
j. Intrusion	0.0561	Very High	1.0000		

[1] Here we consider direct, known gains that the lawful gun owner receives.
[2] Potentialities, things that the gun owner may get at some time in the future.
[3] Direct cost of lawful gun ownership.
[4] The future, potential negative impacts of lawful gun ownership.

Table 6
Collector's perspective

Gun Control Policy:		**Single Shot Policy**		**Totals**	**BO/CR**
Benefits[1]:	**Weights**	Ratings Labels	Ratings Numeric	**Benefits (B)**	**4.5307**
				0.4700	
a. Security & Peace of Mind					
a. Protection	0.05546	Low	0.1236		
b. Respect	0.05546	Medium	0.2515		
c. *Posturing*	0.05546	Low	0.1236		
b. Psychological					
a. Self-esteem	0.03075	Low	0.1236		
b. Identity	0.09531	Low	0.1236		
c. *Turf*	0.01502	Low	0.1236		
d. Community (belonging)	0.04730	High	0.5099		
c. Recreation					
a. Hunting (satisfaction)	0.02135	Absent	0.0650		
b. Ornamental	0.10675	Strong	0.5099		
c. Stress Release	0.10675	Low	0.1236		
d. Target shooting	0.10675	Allowed	1.0000		
d. Constitutional right					
a. Freedom	0.21687	Very Strong	1.0000		
b. Militia	0.04337	No Support	0.0650		
c. Bear arms	0.04337	Low Support	0.1236		
				Opportunities (O)	
Opportunities[2]:	**Weights**			**0.1720**	
a. Appreciation (value)	0.49329	Medium	0.2515		
b. Identity	0.25677	Low	0.1236		
c. 'Insurance' (safety)	0.24994	None	0.0650		
				Costs (C)	
Costs[3]:	**Weights**			**0.1099**	
a. Monetary Costs					
a. Purchase Price	0.04888	Limited	0.1236		
b. Maintenance	0.00978	Low	0.0650		
c. License	0.02186	Low	0.0650		
d. Insurance	0.10930	Low	0.0650		
b. Social costs	0.51340	Minor Injuries (full recovery)	0.1236		
c. Time	0.11613	Simple paperwork	0.1236		
d. Holding (storage)	0.08810	Simple requirement (e.g., lockbox)	0.1236		
e. Reporting	0.09256	No Effort	0.0650		
				Risks (R)	
Risks[4]:	**Weights**			**0.1624**	
a. Constitutionality	0.39245	In Line with the 2nd Ammendment	0.0650		
b. Identity Risks	0.02069	High	0.5099		
c. Liability	0.02658	Some	0.1236		
d. Non-compliance	0.13290	Low	0.1236		
e. Restrictions	0.02507	Extreme restrictions	1.0000		
f. Safety	0.14918	Prevent child misuse	0.2515		
h. Bodily harm to self or others	0.07172	Minor Injuries (full recovery)	0.1236		
i. Surrender	0.12536	Medium	0.2515		
j. Intrusion	0.05606	None	0.0650		

[1] Here we consider direct, known gains that the lawful gun owner receives.
[2] Potentialities, things that the gun owner may get at some time in the future.
[3] Direct cost of lawful gun ownership.
[4] The future, potential negative impacts of lawful gun ownership.

Table 7
Officer's perspective

Gun Control Policy:		**Single Shot Policy**		**Total**	**BO/CR**
Benefits[1]:	**Weights**	Ratings Labels	Ratings Numeric	**Benefits (B)**	**1.7153**
				0.4908	
a. Security & Peace of Mind					
a. Protection	0.0555	Very High	1.0000		
b. Respect	0.0555	Low	0.1236		
c. *Posturing*	0.0555	Low	0.1236		
b. Psychological					
a. Self-esteem	0.0308	Low	0.1236		
b. Identity	0.0953	Medium	0.2515		
c. *Turf*	0.0150	Low	0.1236		
d. Community (belonging)	0.0473	Medium	0.2515		
c. Recreation					
a. Hunting (satisfaction)	0.0214	Weak	0.1236		
b. Ornamental	0.1068	Low Value	0.1236		
c. Stress Release	0.1068	Low	0.1236		
d. Target shooting	0.1068	Allowed	1.0000		
d. Constitutional right					
a. Freedom	0.2169	Very Strong	1.0000		
b. Militia	0.0434	Low Support	0.1236		
c. Bear arms	0.0434	Strong	0.5099		
				Opportunities (O)	
				0.1884	
Opportunities[2]:	Weights				
a. Appreciation (value)	0.4933	Low	0.1236		
b. Identity	0.2568	Medium	0.2515		
c. 'Insurance' (safety)	0.2499	Medium	0.2515		
				Costs (C)	
				0.2250	
Costs[3]:	Weights				
a. Monetary Costs					
a. Purchase Price	0.0489	Moderate	0.2515		
b. Maintenance	0.0098	Moderate	0.1236		
c. License	0.0219	High	0.2515		
d. Insurance	0.1093	Moderate	0.1236		
b. Social costs	0.5134	Substantial injuries (full recovery)	0.2515		
c. Time	0.1161	Paperwork with a waiting period	0.2515		
d. Holding (storage)	0.0881	Simple requirement (e.g., lockbox)	0.1236		
e. Reporting	0.0926	Paperwork with a waiting period	0.2515		
				Risks (R)	
				0.2396	
Risks[4]:	Weights				
a. Constitutionality	0.3924	In Line with the 2nd Ammendment	0.0650		
b. Identity Risks	0.0207	Low	0.1236		
c. Liability	0.0266	Highly liable	0.5099		
d. Non-compliance	0.1329	High	0.5099		
e. Restrictions	0.0251	Limited class (e.g., class 3)	0.1236		
f. Safety	0.1492	Prevent child misuse	0.2515		
h. Bodily harm to self or others	0.0717	Substantial injuries (full recovery)	0.2515		
i. Surrender	0.1254	Low	0.1236		
j. Intrusion	0.0561	Very High	1.0000		

[1] Here we consider direct, known gains that the lawful gun owner receives.

[2] Potentialities, things that the gun owner may get at some time in the future.

[3] Direct cost of lawful gun ownership.

[4] The future, potential negative impacts of lawful gun ownership.

Table 8
Protectionist's perspective

Gun Control Policy: **Single Shot Policy**

	Weights	Ratings Labels	Ratings Numeric	**Total Benefits (B)**	**BO/CR**
Benefits[1]:				**0.1698**	**0.6321**
a. Security & Peace of Mind					
a. Protection	0.0555	None	0.0650		
b. Respect	0.0555	None	0.0650		
c. *Posturing*	0.0555	None	0.0650		
b. Psychological					
a. Self-esteem	0.0308	Low	0.1236		
b. Identity	0.0953	Low	0.1236		
c. *Turf*	0.0150	None	0.0650		
d. Community (belonging)	0.0473	Low	0.1236		
c. Recreation					
a. Hunting (satisfaction)	0.0214	Very Strong	1.0000		
b. Ornamental	0.1068	No Value	0.0650		
c. Stress Release	0.1068	Low	0.1236		
d. Target shooting	0.1068	Strictly Controlled	0.2515		
d. Constitutional right					
a. Freedom	0.2169	Moderate	0.2515		
b. Militia	0.0434	No Support	0.0650		
c. Bear arms	0.0434	Moderate	0.2515		
				Opportunities (O)	
Opportunities[2]:	Weights			**0.1236**	
a. Appreciation (value)	0.4933	Low	0.1236		
b. Identity	0.2568	Low	0.1236		
c. 'Insurance' (safety)	0.2499	Low	0.1236		
				Costs (C)	
Costs[3]:	Weights			**0.1069**	
a. Monetary Costs					
a. Purchase Price	0.0489	No impact	0.0650		
b. Maintenance	0.0098	Low	0.0650		
c. License	0.0219	Moderate	0.1236		
d. Insurance	0.1093	Low	0.0650		
b. Social costs	0.5134	Minor Injuries (full recovery)	0.1236		
c. Time	0.1161	No Effort	0.0650		
d. Holding (storage)	0.0881	Simple requirement (e.g., lockbox)	0.1236		
e. Reporting	0.0926	Simple paperwork	0.1236		
				Risks (R)	
Risks[4]:	Weights			**0.3105**	
a. Constitutionality	0.3924	Moderate Limitations	0.2515		
b. Identity Risks	0.0207	High	0.5099		
c. Liability	0.0266	Some	0.1236		
d. Non-compliance	0.1329	Low	0.1236		
e. Restrictions	0.0251	Extreme restrictions	1.0000		
f. Safety	0.1492	Prevent adult misuse	0.1236		
h. Bodily harm to self or others	0.0717	Substantial injuries (full recovery)	0.2515		
i. Surrender	0.1254	High	0.5099		
j. Intrusion	0.0561	Very High	1.0000		

[1] Here we consider direct, known gains that the lawful gun owner receives.

[2] Potentialities, things that the gun owner may get at some time in the future.

[3] Direct cost of lawful gun ownership.

[4] The future, potential negative impacts of lawful gun ownership.

Table 9 summarizes the total priorities for benefits, opportunities, costs, and risks for the four types of gun owners illustrated in Tables 5-8. Figure 7 shows that information in a radar display that illustrates the similarities and dissimilarities of the four groups.

Table 9
Benefits, Opportunities, Costs, and Risks for four groups of gun owners

	Anti-Gun	Collector	Officer	Protectionist	Ideal	Costly
Benefits	0.2934	**0.4700**	**0.4908**	0.1698	1.0000	0.0650
Opportunities	0.0800	**0.1720**	**0.1884**	0.1236	1.0000	0.0650
Costs	**0.0944**	**0.1099**	0.2250	**0.1069**	0.0650	1.0000
Risks	**0.2621**	0.1624	**0.2396**	0.3105	0.0650	1.0000
BO/CR	0.9494	4.5307	1.7153	0.6321	236.7	0.0040

To bracket the scores, we developed both the ideal state which includes all of the benefits and opportunities and none of the costs or risks, as well as a costly state where there are no benefits or opportunities, and only costs and risks. In the ideal state, the highest score that a given gun policy could achieve is a 236.7, whereas the lowest score that a policy can receive is a 0.004. This provides a bracket for evaluating the impact that gun control policy can achieve. The distance from the ideal or the costly provides some perspective on the overall gain or loss of a proposed policy.

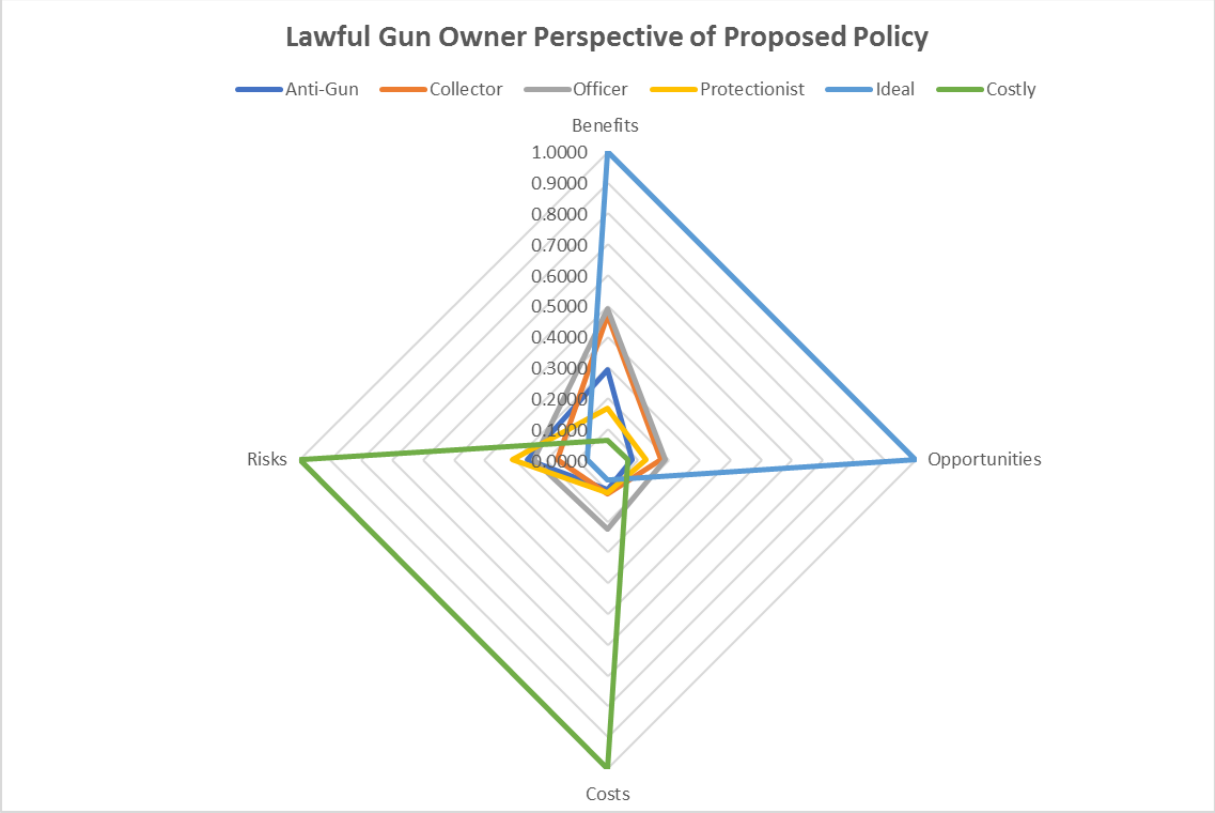


Figure 7 Graphical depiction of proposed fictitious gun control policy

With respect to the consideration of lawful gun owners, the goal is to maximize the volume in the area in the radar chart between the benefits and the opportunities. Note that in Figure 7, the full area between benefits and opportunities is taken up in the ideal state, whereas the full area between costs and risk is taken up in the costly state. In Figure 8, we remove the brackets and focus solely on the four hypothetical types of lawful gun owners in order to more clearly visualize their cases. In Figure 8, we see that the officer's radar chart (grey) has more area in the benefits and opportunities than the collector (orange), but that the officer also has more volume in the costs and risks offsetting the additional area in the benefits; the two have similar area in the opportunities. The result for the two is that the single-shot policy is better from the collector's perspective than from the officer's perspective.

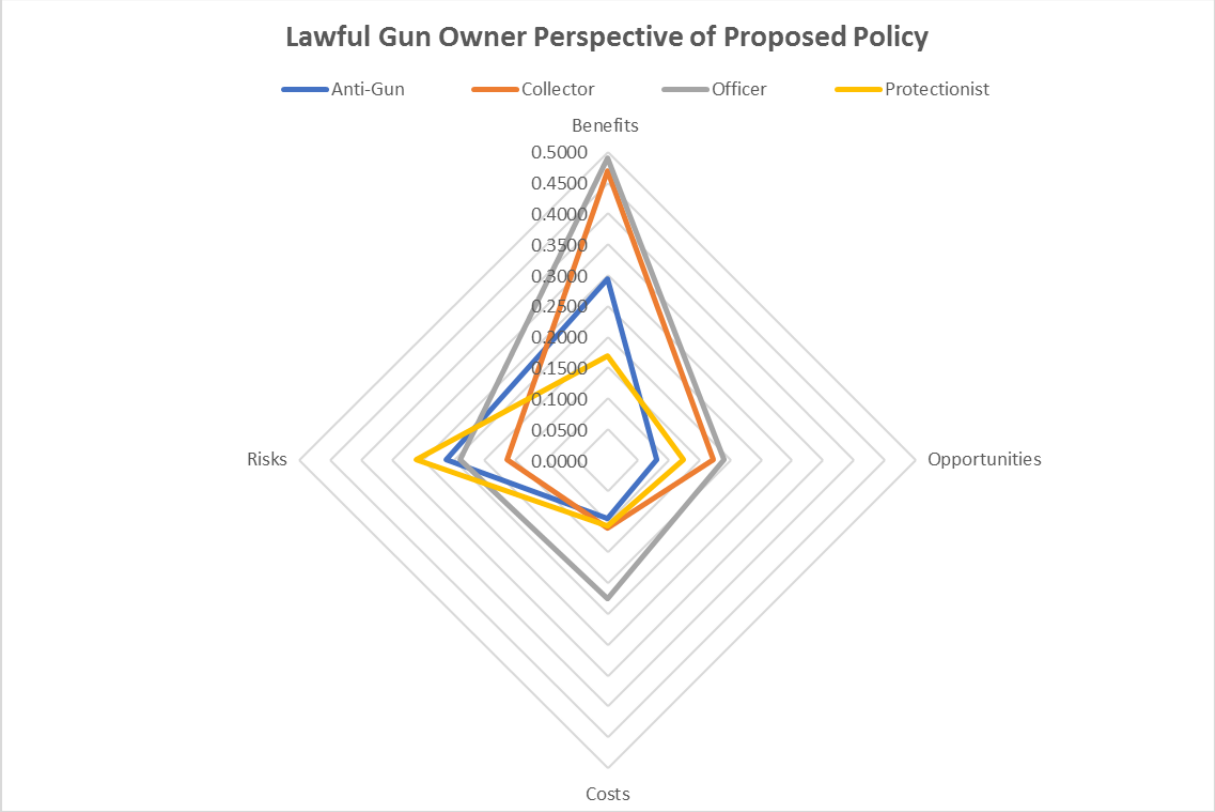


Figure 8 Four perspectives without ideal and costly

The BOCR approach illuminates many ideas. According to benefits and opportunities, the collector and the officer seem in agreement; according to costs the anti-gun activist, the collector and the protectionist seem to agree; and according to risks the protectionist, the anti-gun activist and the officer are closer to each other. These conclusions can be seen in numerical format in Table 9. Overall, the protectionist is most impacted, followed by the anti-gun perspective. The one that benefits most is the collector, but the officer sees more benefits and opportunities than costs and risks.

The implementation of this framework is predicated in two steps:

1. Developing priorities for the strategic criteria for the group profiles, and
2. Evaluating existing or proposed gun control policies by different constituent groups.

The information required to accomplish the first step is predicated on the study of preferences of large groups. The next section describes a methodology that could help attain this objective. Another possibility to accomplish this goal is to use focus groups.

5. How to develop priorities for large groups

Developing priorities for large groups is not the same as achieving consensus for a group in a decision-making situation. In the latter, using the AHP we would seek judgments from decision makers and the geometric mean of those judgments could be used as the representative of the group. Of course, this would require using some statistical analysis to see if the geometric mean really represents the group. In the former, the situation is like voting, but with intensity of preferences. The issue here is how to combine the different judgments. Judgments are from an absolute scale if Saaty's 1-9 scale is used. (Vargas, 2016) showed that each vote is equivalent to a pairwise comparison in which the intensity of preference is very large.

Consider two candidates A_1 and A_2. Comparing them according to a criterion, we can express how strongly we prefer one candidate to the other. For example, if A_1 is preferred to A_2 with intensity *a* the result is a reciprocal matrix of pairwise comparisons given by

$$\begin{array}{c} \\ A_1 \\ A_2 \end{array} \begin{array}{c} \begin{array}{cc} A_1 & A_2 \end{array} \\ \begin{pmatrix} 1 & a \\ a^{-1} & 1 \end{pmatrix} \end{array}$$

The vector of priorities is given by the principal right eigenvector given by

$$\begin{pmatrix} \dfrac{a}{1+a} \\ \dfrac{1}{1+a} \end{pmatrix}$$

that converges to the vector $(1,0)^T$ as $a \to \infty$. Thus, voting for a candidate is equivalent to pairwise comparing them with an intensity of infinity.

When many users are asked for their opinion, the answers (rankings) they provide is called a profile in voting theory. For example, if we ask 100 people how they prefer

candidates A_1 and A_2, if 75 $n_{1>2}=75$ prefer A_1 to A_2 ($n_{1>2}=75$), then 25 should prefer A_2 to A_1 ($n_{2>1}=25$). We assume that there no ties. Then, the profile is written as follows:

$$\phi=\begin{pmatrix}(n_{1>2}) & (n_{2>1})\\ A_1 & A_2\\ A_2 & A_1\end{pmatrix}=\begin{pmatrix}(75) & (25)\\ A_1 & A_2\\ A_2 & A_1\end{pmatrix},$$

and the pairwise voting matrix is given by

$$\begin{array}{c} \\ A_1\\ A_2\end{array}\begin{array}{c}\begin{array}{cc}A_1 & A_2\end{array}\\ \begin{pmatrix}1 & n_{1>2}/n_{2>1}\\ n_{2>1}/n_{1>2} & 1\end{pmatrix}\end{array}=\begin{array}{c} \\ A_1\\ A_2\end{array}\begin{array}{c}\begin{array}{cc}A_1 & A_2\end{array}\\ \begin{pmatrix}1 & 75/25\\ 25/75 & 1\end{pmatrix}\end{array}.$$

If all the voters that prefer A_1 to A_2 have an intensity of preference a_{12}, then we can represent the pairwise voting matrix as follows:

$$\begin{pmatrix}1 & \dfrac{\left(\dfrac{a_{12}}{a_{12}+1}\right)75}{\left(\dfrac{a_{21}}{a_{21}+1}\right)25}\\ \dfrac{\left(\dfrac{a_{21}}{a_{21}+1}\right)25}{\left(\dfrac{a_{12}}{a_{12}+1}\right)75} & 1\end{pmatrix}$$

so that when $a_{12}\to\infty$ we obtain the pairwise voting matrix given above.
The principal right eigenvector of this matrix is given by

$$\begin{pmatrix} \dfrac{\left(\dfrac{a_{12}}{a_{12}+1}\right)75}{\left(\dfrac{a_{12}}{a_{12}+1}\right)75+\left(\dfrac{a_{21}}{a_{21}+1}\right)25} \\ \dfrac{\left(\dfrac{a_{21}}{a_{21}+1}\right)25}{\left(\dfrac{a_{12}}{a_{12}+1}\right)75+\left(\dfrac{a_{21}}{a_{21}+1}\right)25} \end{pmatrix}$$

and when $a_{12} \to \infty$, the voting priorities are given by $\begin{pmatrix} 75/100 \\ 25/100 \end{pmatrix}$.

If all the voters have different intensity of preference $a_{i>j}^{(k)}$, then the pairwise voting matrix is given by

$$\begin{pmatrix} 1 & \dfrac{\sum_{k=1}^{n_{1>2}(\phi)}\left(\dfrac{a_{12}^{(k)}}{a_{12}^{(k)}+1}\right)}{\sum_{k=1}^{n_{2>1}(\phi)}\left(\dfrac{a_{21}^{(k)}}{a_{21}^{(k)}+1}\right)} \\ \dfrac{\sum_{k=1}^{n_{2>1}(\phi)}\left(\dfrac{a_{21}^{(k)}}{a_{21}^{(k)}+1}\right)}{\sum_{k=1}^{n_{1>2}(\phi)}\left(\dfrac{a_{12}^{(k)}}{a_{12}^{(k)}+1}\right)} & 1 \end{pmatrix}.$$

Finally, if we compare *m* candidates, the pairwise voting matrix with intensity of preferences would be given by

$$\begin{pmatrix} 1 & \dfrac{\sum_{k=1}^{n_{1>2}(\phi)} \dfrac{a_{12}^{(k)}}{a_{12}^{(k)}+1}}{\sum_{k=1}^{n_{1<2}(\phi)} \dfrac{a_{21}^{(k)}}{a_{21}^{(k)}+1}} & \cdots & \dfrac{\sum_{k=1}^{n_{1>m}(\phi)} \dfrac{a_{1m}^{(k)}}{a_{1m}^{(k)}+1}}{\sum_{k=1}^{n_{1<m}(\phi)} \dfrac{a_{m1}^{(k)}}{a_{m1}^{(k)}+1}} \\ - & 1 & \cdots & \dfrac{\sum_{k=1}^{n_{2>m}(\phi)} \dfrac{a_{2m}^{(k)}}{a_{2m}^{(k)}+1}}{\sum_{k=1}^{n_{2<m}(\phi)} \dfrac{a_{m2}^{(k)}}{a_{m2}^{(k)}+1}} \\ \vdots & \vdots & \ddots & \vdots \\ - & - & \cdots & 1 \end{pmatrix} \qquad (3)$$

where $n_{i>j}(\phi)$ and $a_{ij}^{(k)}$ represent the number of voters that prefer *i* to *j* and the intensity with which the k^{th} voter prefers *i* to *j*, respectively. Note that if $a_{ij}^{(k)} \to \infty,$ for all i and j , the pairwise voting matrix converges to the matrix

$$\begin{pmatrix} 1 & w_{12}(\phi) & \cdots & w_{1m}(\phi) \\ w_{21}(\phi) & 1 & \cdots & w_{2m}(\phi) \\ \vdots & \vdots & \ddots & \vdots \\ w_{m1}(\phi) & w_{m2}(\phi) & \cdots & 1 \end{pmatrix}$$

where $w_{ij}(\phi) = \dfrac{n_{i>j}(\phi)}{n_{j>i}(\phi)}$, $n_{j>i}(\phi) > 0$, and the voting priorities of the m candidates are given by the principal right eigenvector of the matrix.

Consider the following profile in which four alternatives are compared by 14 individuals:

$$\begin{matrix} (4) & (3) & (5) & (2) \end{matrix}$$
$$B = \begin{pmatrix} a_1 & a_2 & a_3 & a_4 \\ a_2 & a_3 & a_4 & a_1 \\ a_3 & a_4 & a_1 & a_2 \\ a_4 & a_1 & a_2 & a_3 \end{pmatrix}.$$

If we were to use the counting method, the voting priorities are given by the principal right eigenvector of the matrix:

Counting	*a1*	*a2*	*a3*	*a4*	Priorities
a1	1	11/3	6/8	4/10	0.2436
a2	3/11	1	9/5	7/7	0.2027
a3	8/6	5/9	1	12/2	0.3589
a4	10/4	7/7	2/12	1	0.1948

Let us now consider that each decision maker has her own intensity of preference according to Table 10. Combining the intensity of preferences as in Equation 3, we obtain the following matrix:

Ranking		*a1*	*a2*	*a3*	*a4*	Priorities
	a1	1	3.400928	0.789474	0.557616	0.2634
	a2	0.294037	1	1.734146	1.026261	0.2095
	a3	1.266667	0.576653	1	5.463415	0.3477
	a4	1.793349	0.974411	0.183036	1	0.1794

which yields priorities close to the priorities produced by the ranking method. On the other hand, the matrix of geometric means given by yield priorities that are not as close to the priorities obtained by the Ranking method. Thus, we believe that a way to capture priorities of large groups is by using the ranking method within the context of the eigenvector method of pairwise comparisons.

GM		a1	a2		a3	Priorities
	a1	1	2.013483	0.923194	0.6671	0.2624
	a2	0.496652	1	1.237874	1.076316	0.2220
	a3	1.083195	0.807837	1	2.336644	0.2958
	a4	1.499026	0.929095	0.427964	1	0.2198

Table 10
Profile B intensity of preferences

a1>a2>a3>a4

	a1	a2	a3	a4	Priorities
a1	1	3	5	9	0.5806
a2	0.333333	1	3	5	0.2554
a3	0.2	0.333333	1	3	0.1141
a4	0.111111	0.2	0.333333	1	0.0499

	a1	a2	a3	a4	Priorities
a1	1	5	7	9	0.6485
a2	0.2	1	3	5	0.2009
a3	0.142857	0.333333	1	5	0.1100
a4	0.111111	0.2	0.2	1	0.0407

	a1	a2	a3	a4	Priorities
a1	1	2	3	5	0.4650
a2	0.5	1	3	5	0.3273
a3	0.333333	0.333333	1	2	0.1342
a4	0.2	0.2	0.5	1	0.0736

	a1	a2	a3	a4	Priorities
a1	1	4	5	7	0.5758
a2	0.25	1	4	6	0.2613
a3	0.2	0.25	1	5	0.1187
a4	0.142857	0.166667	0.2	1	0.0442

a2>a3>a4>a1

	a1	a2	a3	a4	Priorities
a1	1	0.142857	0.2	0.333333	0.0521
a2	7	1	5	5	0.6194
a3	5	0.2	1	3	0.2195
a4	3	0.2	0.333333	1	0.1090

	a1	a2	a3	a4	Priorities
a1	1	0.2	0.333333	0.333333	0.0720
a2	5	1	3	3	0.4925
a3	3	0.333333	1	5	0.3051
a4	3	0.333333	0.2	1	0.1304

	a1	a2	a3	a4	Priorities
a1	1	0.166667	0.2	0.333333	0.0503
a2	6	1	7	7	0.6584
a3	5	0.142857	1	5	0.2106
a4	3	0.142857	0.2	1	0.0807

a3>a4>a1>a2

	a1	a2	a3	a4	Priorities
a1	1	5	0.2	0.333333	0.1364
a2	0.2	1	0.142857	0.2	0.0489
a3	5	7	1	3	0.5558
a4	3	5	0.333333	1	0.2589

	a1	a2	a3	a4	Priorities
a1	1	4	0.333333	0.2	0.1272
a2	0.25	1	0.142857	0.333333	0.0547
a3	3	7	1	5	0.5646
a4	5	3	0.2	1	0.2536

	a1	a2	a3	a4	Priorities
a1	1	7	0.5	0.333333	0.2082
a2	0.142857	1	0.2	0.2	0.0536
a3	2	5	1	2	0.4070
a4	3	5	0.5	1	0.3312

	a1	a2	a3	a4	Priorities
a1	1	3	0.2	0.2	0.0978
a2	0.333333	1	0.2	0.2	0.0576
a3	5	5	1	5	0.5885
a4	5	5	0.2	1	0.2560

	a1	a2	a3	a4	Priorities
a1	1	5	0.2	0.333333	0.1364
a2	0.2	1	0.142857	0.2	0.0489
a3	5	7	1	3	0.5558
a4	3	5	0.333333	1	0.2589

a4>a1>a2>a3

	a1	a2	a3	a4	Priorities
a1	1	3	5	0.111111	0.1733
a2	0.333333	1	3	0.2	0.0967
a3	0.2	0.333333	1	0.142857	0.0473
a4	9	5	7	1	0.6828

	a1	a2	a3	a4	Priorities
a1	1	5	7	0.2	0.2844
a2	0.2	1	5	0.333333	0.1259
a3	0.142857	0.2	1	0.2	0.0466
a4	5	3	5	1	0.5431

6. Implementation of the proposed approach

Thus far, we have illustrated an approach that may be used to develop a measure of the impact of existing and proposed gun policies for lawful gun owners. Assessing the impact of gun policies on lawful gun owners is an important activity since the implementation of any policy may impose unintended hardships on them. While the legislation of any policy is ultimately carried out with the best intentions, without considering the impact on the gun owner the full impact of the policy is unknown.

In this effort, the authors assumed the roles of the various stakeholders for sake of illustration. To fully develop the models requires much more involvement and greater input. Since gun policies are developed at every level of our government, and gun owners are varied, the final assessment needs to reflect the various levels and types of gun owners. To this end, we propose additional work that needs to be conducted as follows:

1. Identification of national-level focus groups with subject matter experts,
2. Identification of state-level focus groups with subject matter experts,
3. Hold discussions with gun-owner focus groups,
4. Develop criteria,
5. Develop a distributed platform for priority generation, and
6. Estimate policy and law ratings.

National and state-level focus groups will provide greater insights into what the criteria for evaluation should be. The results will be a hierarchical structure that more accurately reflects the criteria and priorities at each level. Ideally, each state should have a focus group study done such that the criteria that are important to that state and the resultant priorities accurately reflect the state's interests.

The results from the focus groups can be put into a web-based platform for distributed release. The platform will allow users to input their own ratings on existing and proposed legislation to see their resulting scores. The collection of the data along with demographics will facilitate a continuous evaluation of the BO/CR of gun policy in the U.S. that will be updated as priorities and concerns shift and change.

7. How to use the results of the study

Disagreement between different gun advocate groups is one of the most important issues confronting American society. According to (Pierre, 2019),

> "The gun debate in America is often framed as a stand-off between two immutable positions with little potential to move ahead with meaningful legislative reform. Attempts to resolve this impasse have been thwarted by thinking about gun ownership attitudes as based on rational choice economics instead of considering the broader socio-cultural meanings of guns."

In this paper, we present a mechanism to begin a dialogue between different stakeholders in the hope that by identifying the differences in thinking a compromise can be reached. By measuring the impact of a gun policy (law) on different groups one could perhaps modify, in incremental steps, the policy being evaluated, so that the groups can be closer to each other in most of the issues they consider important. It is possible that by using this methodology some groups may discover some misinterpretations or misunderstandings they have about the policy that can help them feel more at ease with it or know how they could lobby for or against it.

The focus groups must consist of knowledgeable people from the different constituencies. Experience suggests the recommended size of each group should be between five and ten people (Cummings et al., 1974). We would need a session to develop priorities for the strategic criteria, the benefits, the opportunities, the costs, and the risks, and a second session to evaluate different gun control policies. It is possible that this evaluation could be done through an electronic questionnaire, in which case it may not be easy to determine who is answering the evaluation. However, given the importance of this step it is preferable to use focus groups.

This paper facilitates the development of a proof of concept to show that our methodology captures what stakeholders think about different gun laws and their impact on lawful gun owners. This will enable policy makers to develop policies that are beneficial to society at large. Ultimately, the validity of our proof of concept will result in the development of a distributed platform. This platform will enable any stakeholder to rate a proposed/existing policy, and thereafter, policy makers can assess its impact and legislate accordingly.

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APPENDIX A: RELATIVE MEASUREMENT

Relative measurement is the development of a scale to measure an intangible attribute, i.e., an attribute for which no scale to measure exists. Thus, each individual has its own scale in mind. However, if there were a scale to measure the attribute, relative measurement would provide an answer in relative terms. For example, consider that we want to measure the weight of three cantaloupes, C_1, C_2 and C_3, but we do not have a weight scale with us. So, we get two cantaloupes, C_1 and C_2, one in each hand and we try to feel which one is heavier. We do that with each pair of cantaloupes, (C_1, C_2), (C_1, C_3) and (C_2, C_3). We cannot compare all of them at once. Each pairwise comparison gives us an estimate of relative heaviness, but how do we decide which one is heaviest? If we decide that between C_1 and C_2, C_2 is heaviest, then we can compare C_2 and C_3 and we are done. Suppose that C_2 is the heaviest of the three cantaloupes, so we buy C_2. However, our result did not give us an estimate of how much heavier C_2 is than the other two cantaloupes. If the store were to give us the actual weights of the cantaloupes, w_1, w_2 and w_3, we could estimate, when we compared C_1 and C_2 balancing them on our hands, which one is heavier with the ratio w_1/w_2 or w_2/w_1. It is easiest to estimate how much heavier the heavier one is, as a function of the lighter one, than vice versa. This is equivalent to what is known in psychometrics as fractionation and multiplication. If we arrange these comparisons in a matrix form, we have:

$$\begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & C_3 \end{array} \\ \begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \frac{w_1}{w_3} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \frac{w_2}{w_3} \\ \frac{w_3}{w_1} & \frac{w_3}{w_2} & \frac{w_3}{w_3} \end{bmatrix} \end{array} \qquad \text{(A.1)}$$

Note that in Equation A.1 we took the ratio of the weights. The result is a number without units. It is an absolute number. On the other hand, had we taken the differences, e.g., $w_1 - w_2$, if the weight is given in pounds, the difference will be in pounds. Thus, taking the ratio to estimate the weight does not need a scale unit. All we need to do is estimate in absolute terms how much heavier one is than the other one.

The next step is to obtain from the ratio comparisons $\left\{ w_i \Big/ w_j \right\}$ the relative weights of the objects. Relative weights would be $\left\{ \frac{w_1}{w_1+w_2+w_3}, \frac{w_2}{w_1+w_2+w_3}, \frac{w_3}{w_1+w_2+w_3} \right\}$. It turns out that if we multiply the first column by w_1, the second by w_2, and the third one by w_3, and sum across the rows we get:

$$\begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & C_3 \end{array} \\ \begin{bmatrix} \frac{w_1}{w_1}\times w_1 & \frac{w_1}{w_2}\times w_2 & \frac{w_1}{w_3}\times w_3 \\ \frac{w_2}{w_1}\times w_1 & \frac{w_2}{w_2}\times w_2 & \frac{w_2}{w_3}\times w_3 \\ \frac{w_3}{w_1}\times w_1 & \frac{w_3}{w_2}\times w_2 & \frac{w_3}{w_3}\times w_3 \end{bmatrix} \end{array} = \begin{bmatrix} 3w_1 \\ 3w_2 \\ 3w_3 \end{bmatrix}.$$

Thus, we recover the weights by dividing each value by the sum of all the values, and this would yield the relative weights of the objects:

$$\left\{ \frac{w_1}{w_1+w_2+w_3}, \frac{w_2}{w_1+w_2+w_3}, \frac{w_3}{w_1+w_2+w_3} \right\}$$

In real life, we may not know the weights, but we may be able to guess them by assigning a positive number. For example, we could have the following matrix:

$$\begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & C_3 \end{array} \\ \begin{bmatrix} 1 & a & b \\ 1/a & 1 & c \\ 1/b & 1/c & 1 \end{bmatrix} \end{array}. \qquad \text{(A.2)}$$

In matrix notation, entry, e.g., (1,2), represents the row number = 1, and the column number = 2. Note that the entries in the positions (1,1), (2,2) and (3,3) are now 1, the result of dividing a positive number by itself. The entries in the transposed positions, i.e., the transposed entry of (1,2) is the entry in the (2,1) position, are the reciprocal of the original entries, e.g., if entry (1,2) is *a* then the entry (2,1) is 1/*a*.

Now the entries of the matrix of pairwise comparisons are educated guesses of the underlying ratios of the weights we seek. To estimate the relative weights, (Saaty 1980) proposed a first order approximation by first normalizing to unity each of the columns, and then averaging the resulting rows. For the matrix given in (A.2) we would have:

$$\begin{bmatrix} 1 & a & b \\ 1/a & 1 & c \\ 1/b & 1/c & 1 \end{bmatrix} \rightarrow \begin{bmatrix} 1/(1+\frac{1}{a}+\frac{1}{b}) & a/(a+1+\frac{1}{c}) & b/(b+c+1) \\ (1/a)/(1+\frac{1}{a}+\frac{1}{b}) & 1/(a+1+\frac{1}{c}) & c/(b+c+1) \\ (1/b)/(1+\frac{1}{a}+\frac{1}{b}) & (1/c)/(a+1+\frac{1}{c}) & 1/(b+c+1) \end{bmatrix}$$

$$\rightarrow \begin{bmatrix} \{[1/(1+\frac{1}{a}+\frac{1}{b})]+ & [a/(a+1+\frac{1}{c})]+ & [b/(b+c+1)]\}/3 \\ \{[(1/a)/(1+\frac{1}{a}+\frac{1}{b})+ & [1/(a+1+\frac{1}{c})]+ & [c/(b+c+1)]\}/3 \\ \{[(1/b)/(1+\frac{1}{a}+\frac{1}{b})]+ & [(1/c)/(a+1+\frac{1}{c})]+ & [1/(b+c+1)]\}/3 \end{bmatrix}$$

.

The mathematical model that provides the solution to our estimation problem is known as a principal eigenvalue problem. We refer to the reader to (Saaty 1977) for details of this model.

The importance of this model lies with the fact that now we can estimate relative measures for intangible attributes. (Saaty 1977) used the absolute scale given in Table 1 to estimate the pairwise comparisons. Remember that the scale in Table 1 is an estimate. If actual measurement were available, we could use those to compute the relative weights.

Table 1
Fundamental scale

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly favor one activity over another
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals of above	If activity *i* has one of the above nonzero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*	
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining *n* numerical values to span the matrix

The first experiment performed to try to validate perception with the fundamental scale of Table 1 was the optics experiment (Saaty 1977). Four objects were placed at the following distances measured in yards from a light source: 9, 15, 21, 28. In normalized form these distances are 0.123, 0.205, 0.288, 0.384. Next, two independent sets of judges were asked to estimate pairwise comparisons of the brightness of the objects, labeled in increasing order according to their nearness to the source where the judges were located. The result was two pairwise comparison matrices:

1st Trial

	C_1	C_2	C_3	C_4
C_1	1	5	6	7
C_2	1/5	1	4	6
C_3	1/6	1/4	1	4
C_4	1/7	1/6	1/4	1

2nd Trial

	C_1	C_2	C_3	C_4
C_1	1	4	6	7
C_2	1/4	1	3	4
C_3	1/4	1/3	1	2
C_4	1/7	1/4	1/2	1

The relative brightness from the trials was:

Relative brightness (1st trial)	Relative brightness (2nd trial)
0.61	0.62
0.24	0.22
0.10	0.10
0.05	0.06

There is a law in optics known as the inverse square law that states that the brightness of an object located at a distance from a source of light is inversely related to the square of the distance of the object to the source of light. Table 2 gives the inverse square law of the four objects considered.

Table 2
Inverse square law of optics

Distance	1/Distance^2	Normalized Distance^2	1st Trial	2nd Trial
9	0.01234568	0.607	0.61	0.62
15	0.00444444	0.218	0.24	0.22
21	0.00226757	0.112	0.10	0.10
28	0.00127551	0.063	0.05	0.06

Note that after applying the inverse square law of optics to the distances, the relative values (6th column of Table 2) are very close to the estimates of relative brightness obtained in the two trials. There are many experiments like this that support the idea that

judgments could be used to estimate in relative terms the importance of intangibles in decision making.

In measurement theory, when a set of objects, or alternatives in general, are compared, they must always be compared with respect to one criterion and only one criterion at a time. No comparison can take place without a criterion in mind. When multiple criteria are involved, we must compare the alternatives with respect to each of the criteria. What makes relative measurement so interesting is that we can now combine the relative scales because they are all measured in the same units. Since the criteria may not be equally important one could think about using a weighted average of the different relative scales. There are different opinions as to how to combine the different scales obtained from each criterion, but if one is careful when defining the criteria so that they do not overlap in meaning, the weighted average is usually a good estimate. This is known as *hierarchical synthesis* because instead of criteria and alternatives, one could think of criteria, sub-criteria, sub-criteria of sub-criteria and so on, all the way down the hierarchy to the alternatives that usually occupy the bottom level of the hierarchy. The top level of the hierarchy is the goal.

A logical extension of the Analytic Hierarchy Process is the Analytic Network Process (Saaty 1996). Instead of considering hierarchies as in Figure A.1, we consider a network of relations between the criteria, the sub-criteria, the alternatives, and so on as in Figure A.2. An important characteristic of networks is that they allow for feedback between clusters.

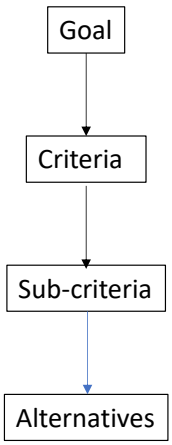

Figure A.1. A Hierarchy

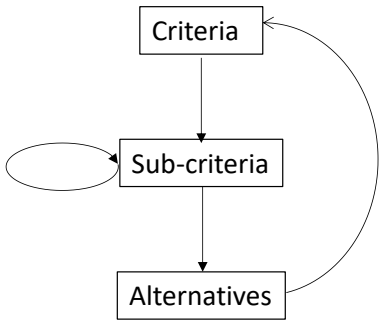

Figure A.2. A network

For example, when comparing a diagnostic procedure for a disease, alternative procedures need to be prioritized with respect to, for example, accuracy, simplicity, logistics, invasiveness and so on. But, to select a procedure we need to assign priorities to the criteria. However, each procedure could perform better under different criteria. There may be statistics that tell us, for a given procedure, under which criterion it performs better. This would be equivalent to comparing the criteria or attributes of the procedures

under each alternative. This is a feedback loop from the cluster of alternatives to the cluster of criteria.

APPENDIX B: DEFINITIONS

Cluster – a grouping of nodes that share a similar class within the AHP / ANP model.
Collectors – this category of gun owner tends to possess them for the potential appreciation in value. They may display their guns and could have many in their possession.
Enthusiasts – these are generally people who feel an affinity with guns.
Gun shop owners - Dealers
Historical reenactment – this category may have weapons for recreating battles such as Gettysburg, may participate in demonstrations such as Veteran's Day parades, or take part in filming.
Hunters – there are a variety of types of hunters. For instance, a bird hunter might prefer a shotgun, whereas a deer hunter might prefer cartridge. There are some hunters that prefer black-powder, whereas some others may prefer high-power. Some hunters hunt for recreation, whereas others hunt to supplement their food. We do not separate the various types of hunters, but recognize there is a variety.
Law enforcement – these individuals will often be issued a service weapon, but may also have personal weapons that they may decide to carry while working and may also carry while off-duty.
Node – an individual unit or member of a cluster that shares some characteristic of the other members within the cluster of the AHP / ANP model.
Paramilitary – these individuals may possess weapons for the purpose of serving in a militaristic type of organization which is not government backed or supported.
Private citizens – homeowners, personal protection, automobile.
Private security guards – these individuals are typically contracted out through a firm to cover banks, buildings, and other locations. They may be required to own their own gun though their employer may provide one.
Retired and active duty military – military members may have basic weapons training but may also have advanced weapons training. These individuals may have a variety of types of weapons.
Shooting – paper fixed targets, skeet, and pop-up.
Survivalists – these individuals may purchase weapons with the idea of needing them should social structures and services fall into disarray.

APPENDIX C: ACRONYMS

AHP – Analytic Hierarchy Process
ANP – Analytic Network Process