Hunting for a Better Market Design: Hunting Permits in Montana

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Abstract

The Montana hunting permit market organized by Montana Fish, Wildlife and Parks is an important market for allocating permissions to hunt. In this paper, I study the current hunting permit lottery and the probabilities of winning the permit lotteries and evaluate the pros and cons of the market. I then propose two versions of VCG auctions which could potentially be improvements to the current system. I recommend the use of my created VCG Version 1 auction for permits due to its efficient allocation and relative ease of participant use, although its computational viability needs to be investigated further.

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1 Introduction

Hunting is a popular outdoors activity in Montana with Montana Fish, Wildlife and Parks (FWP) estimating that over 200,000 people participate every year (FWP, 2022c). This popularity is due to the abundance and variety of wild animals that Montana has to offer, which includes more commonly hunted animals such as deer and elk as well as animals unique to the Western United States such as bison and big horn sheep. However, the large popularity of the activity has a problem: there is a limited number of the animals that can be hunted. In order to accommodate this scarcity, the Montana FWP, who is in control of the supply of the wild animals, must determine how to manage the amount of animals hunted.

As part of Montana FWP's goal of animal conservation, they decide how to allocate hunting licenses and permits, which give people permission to hunt for certain animals. These permits help limit the amount of animals hunted and where they are hunted. This allows for the FWP to evaluate the population levels of the different species and to adjust how much they are hunted in future years. The permit allocation can also be used for conservation through the revenue that it generates through the selling of permits, which can be used for a variety of conservation projects. Together, these two parts of the permit system are used by the FWP to protect the wildlife and the environment in the Montana.

These permit markets also work to help the economy, by keeping a well stocked population of wild animals. A large population of wild animals can help bring more people out to hunt, which means more people are spending money on hunting related equipment. It is also a big draw for tourism, bringing in many non-residents to spend money in Montana.

Hunting can add significant money to the Montana economy, with in 2016 Montana FWP estimated that deer, elk and antelope hunters spent over $324 million dollars and helped support over 3,300 jobs in Montana (FWP, 2016).

Since this is an important market, I use principles from the economics of market design to study what the Montana hunting permit market does well and what are its problems. The major benefit of the current system is that it uses a lottery mechanism to allocate permits, which makes it easy for participants to use, but the issue is that this does not provide efficient allocation of permits. Therefore, in this paper I study the current Montana hunting permit market, propose two different potential improvements to the current market through modifications of VCG auctions, and evaluate the pros and cons of implementing such auctions.

The paper proceeds as follows: Section 2 gives background on the current hunting permit market and gives some upper and lower bounds for probabilities of getting a permit in the current lottery system. Section 3 evaluates the current market. Section 4 describes research on markets for radio spectrum, which are similar to hunting permits. Section 5 proposes two potential market improvements, and section 6 evaluates these markets. Finally, section 7 concludes.

2 Current Hunting Permit Market in Montana

In this section I summarize the the current Montana hunting market system using information from 2022 Montana FWP hunting guides (FWP, 2022b,a). First, some basic definitions of important hunting objects in Montana. A *General License* is a species specific license that allows one to hunt a single animal of the specified species in any non-restricted area. For residents of Montana, these are available for purchase online or over the counter at designated retailers with one per person per species (i.e someone can have one deer general license and one elk general license, but not two deer general license). The case for non-residents is slightly different, but I will restrict my analysis to the case only for residents.

Next is a *Hunting Permit*, which is a species AND district specific addition to one's general license, allowing one to hunt in certain restricted districts. Before one can get a for a species permit, they must first have the general license of that same species. Both the permit and the general licenses cannot be traded or bought from others and must be acquired from designated retailers. A map of the different hunting districts are included in Figure 1.

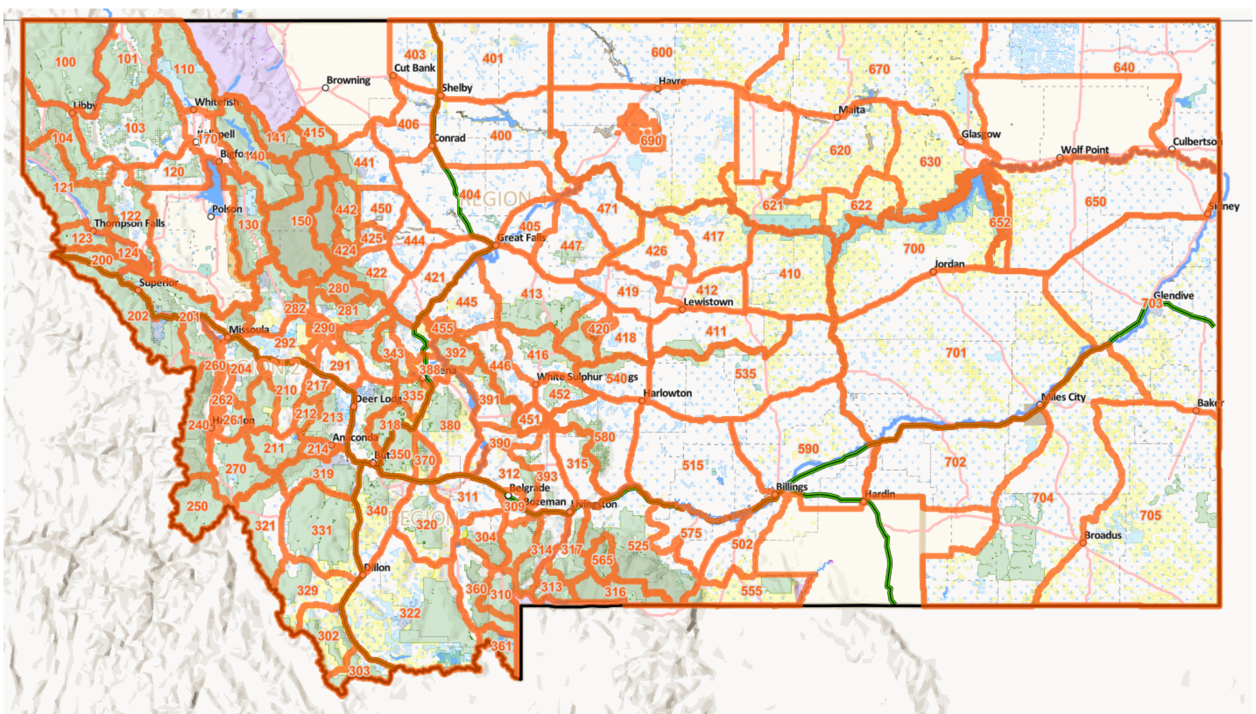

Figure 1: Map of Hunting Districts in Montana
Source: Montana Fish, Wildlife, and Parks Hunt Planner

Although permits are not necessary to be able to hunt, the areas where these permits allow you to hunt in areas with higher either that is either more densely populated with animals or that has higher quality animals. Additionally, there are some more specialty animals such as bison or moose that are only available as permits/license combinations in drawings. Overall, acquiring a hunting permit enhances the potential hunting trip, especially when compared to the areas open to the public where you are competing against more people.

An important part of the hunting permit process is the drawing system. Each animal species has their own draw, in which one lists the top three choices for districts where they want the permit. For one's top choice there is an additional feature, called "Bonus Points", which are meant to increase your odds of winning if you did not win in the previous years. Each year, one bonus point can be bought per species and they are not transferable among different species or other people. The bonus points work by adding the squared number of bonus points in addition to your application to your draw. For example, if you have 3 bonus points then you will get 9 chances from your bonus points plus your application for a total of 10 entries into the drawing. If you get your first choice then your bonus points are used up, otherwise you keep them for next year.

The drawings work by first drawing for everyone's first choice and then everyone who wins is then removed. Then the drawings repeat for everyone's second choice and the winners are removed. Finally, the drawings repeat for the third and final round. Note, in the second and third rounds the supply might already be gone from the first round drawings, so it is wise to make sure one's second and third choices are not in high demand to ensure a backup. Additionally, since there are no bonus points in these last two rounds, if there is still available supply, everyone has an equal chance of winning. For a listing of some examples of first choice drawing odds, see figure 2.

Key: LPT = License/Permit Type. The first three digits most often represent the hunting district number.
Apps = Total number of resident and nonresident 1st-choice applicants.
Succ = Total number of resident and nonresident 1st-choice applicants that were successful.
% Succ = Percentage of resident and nonresident 1st-choice applicants that were successful.

Deer Permits – 2021 First Choice Drawing Statistics

LPT	Apps	Succ	% Succ	LPT	Apps	Succ	% Succ	LPT	Apps	Succ	% Succ	LPT	Apps	Succ	% Succ
103-50	330	13	3.94	240-50	89	25	28.09	292-50	380	380	100	403-50	19	19	100
109-50	142	10	7.04	240-51	180	180	100	300-50	1114	30	2.69	403-51	20	5	25
130-50	201	10	4.98	250-50	441	25	5.67	312-50	743	75	10.09	406-50	42	35	83.33
202-50	570	150	26.32	261-50	1222	15	1.23	319-50	178	178	100	406-51	87	20	22.99
204-50	158	158	100	262-51	345	30	8.7	324-50	1403	25	1.78	441-50	864	35	4.05
210-50	852	50	5.87	262-52	69	10	14.49	380-50	928	928	100	455-60	1340	15	1.12
212-50	73	73	100	270-50	8795	45	0.51	392-50	360	360	100	530-50	1272	650	51.1
213-50	225	225	100	270-51	431	15	3.48	400-50	123	90	73.17	652-50	1628	200	12.29
214-50	34	34	100	281-50	157	157	100	400-51	86	20	23.26				
215-50	262	262	100	291-50	994	30	3.02	401-50	211	75	35.55				
217-50	57	57	100	291-51	152	30	19.74	401-51	177	65	36.72				

Figure 2: 2021 First Choice Deer Permit Drawing Statistics
Source: 2022 Deer— Elk— Antelope: Montana FWP Hunting Regulations

Then if you win the lottery, you pay for your permit. The prices for the permit vary depending the species, with deer priced at \$5.00, while the Bighorn Sheep, Bison, Moose, and Mountain Goat permit/license combo are all priced at \$125.00.

In the following two subsections, I study the probability of winning a permit from one's first choice in the lottery. Since it is hard to solve for a general case, I propose some simplifying assumptions and create a lower and upper bounds to the probability of winning a permit given certain parameters.

2.1 Modeling the Probabilities: Lower Bound

When entering a lottery for your first choice, the worst case scenario is when everyone else applies for bonus points and you do not get any bonus points. In this scenario, I present a model in which everyone starts with no bonus points and then everyone except for us opts into the bonus point system each year. Some additional simplifying assumptions I am making are that the total number of individuals entering the lottery system and the supply of permits is constant over time. I also assume everyone in the model is a resident. One more assumption that I am making that does not reflect the true system, is that after people win that they do not lose bonus points. This assumption allows us our probabilities in a given year to be independent of how the previous years lottery and also allows us to have that people have i bonus points in year i. By studying this scenario, we can estimate a lower bound for the probability of winning a permit.

For an individual drawing of the lottery in a given year, we have that the probability of being drawn is

$$Pr(\text{Win}|\text{Year}) = \frac{\text{Individual Entries}}{\text{Total Entries}}$$

and in our case, the number of entries for an individual is just 1 because we are not applying for bonus points. For total entries, since everyone else is applying for bonus points and since the bonus points are squared, we have that in year i,

$$\text{Total Entries} = N + (N-1)(i^2)$$

where N is the total number of people who entered.

Therefore, the probability of us winning in a given year is

$$Pr(\text{Win}|\text{Year} = i) = \frac{1}{N + (N-1)(i^2)}$$

We can see that our probability of winning in a given year decreases with more years because everyone else is gaining bonus points, while we are left with a single entry.

However, this is just for a drawing with a single permit, while there is almost always more than one permit being drawn. In these drawings, once someone wins, they cannot win again, so all of their entries are removed from the pool, and it is drawn again. Therefore, for us to win, we either need to win on the first drawing, or someone else wins and their entries are removed, then we can win on the second win or if we lose the winner is removed, and so on for each of the permits being allocated.

First, we define the probability of winning on the jth draw in year i as

$$p_{i,j} = \frac{1}{N + (N-1)(i^2) - j(1+i^2)}$$

Now, the probability of us winning in a drawing with n different drawings in year i is:

$$p_i := Pr(\text{win}|\text{year} = i) = \sum_{k=0}^{n} \left(p_{i,k} \prod_{j=0}^{k-1} (1 - p_{i,j}) \right)$$

because this is the sum of probabilities of winning at any stage in the drawing, given you lost at all of the previous stages of the drawing.

Now, we are interested in the probability of winning at least one permit over multiple years. This is equivalent to finding 1 minus the probability of losing every year, which we can write as

$$P_m^{worst} := Pr(\text{Win} \geq 1|m) = 1 - \prod_{i=1}^{m} (1 - p_i)$$

where m is the number of years we are looking over.

Now looking at a particular example, from the 2021 lottery system for deer permits in area 261 there were 1,222 people who applied for this permit with their first choice and there were only 15 permits that were distributed. Using these numbers, we get that $N = 1222$ and $n = 15$.

For a single year, we first see that

$$p_{i,j} = \frac{1}{1222 + (1222 - 1)(i^2) - j(1 + i^2)}$$

and that

$$P_1^{worst} = Pr(\text{Win}|\text{Year} = 1) = \sum_{k=0}^{15} \left(p_{i,k} \prod_{j=0}^{k-1} (1 - p_{i,j}) \right) \approx 0.00657$$

so there is a 0.657% chance of winning.

If we additionally look at the probability of winning at least once over the first 5 years, we first see that

$$p_{i,j} = \frac{1}{1222 + (1222 - 1)(i^2) - j(1 + i^2)}$$

so we get

$$p_i = Pr(\text{win}|\text{year} = i) = \sum_{k=0}^{15} \left(p_{i,k} \prod_{j=0}^{k-1} (1 - p_{i,j}) \right)$$

and finally

$$P_5^{worst} = Pr(\text{Win} \geq 1|m = 5) = 1 - \prod_{i=1}^{5} (1 - p_i) \approx 0.0118$$

so you only have a 1.18% chance of winning at least one permit over a 5 year period in this scenario. Keep in mind that this is the lower bound of our probability, so this is really saying that we have greater than 1.18% chance of winning, given everyone is starting with no bonus points.

2.2 Modeling the Probabilities: Upper Bound

The best case scenario is when you opt into the bonus point system every year, while everyone else does not. Keeping the same assumptions that everyone starts with no bonus points and that the bonus points do not reset after winning, we have that in year i, we will have i bonus points while everyone else has 0 bonus points.

First, the probability of winning when there is a only a single permit is

$$Pr(\text{Win}|\text{Year} = i) = \frac{1 + i^2}{N + i^2}$$

because we have $1 + i^2$ entries and everyone else only has 1 entry into the lottery.

Now, when there are n permits being allocated, this probability of winning on the jth draw in year i is

$$Pr(\text{Win}|\text{Year} = i) = p_{i,j} = \frac{1}{N + i^2 - j}$$

because only one entry is removed when someone besides us wins, so on the jth drawing, there are j less entries in the pool.

We can then define the probability of winning in ith year with n permits to be

$$p_i := Pr(\text{win}|\text{year} = i) = \sum_{k=0}^{n} \left(p_{i,k} \prod_{j=0}^{k-1} (1 - p_{i,j}) \right)$$

Now, we can take into account winning over multiple years. We have that the probability of winning at least once is over the first m years of participating is:

$$p_m^{best} = Pr(\text{win} \geq 1|m) = 1 - \prod_{i=1}^{m} (1 - p_i)$$

Now, going back to our previous example from earlier, in area 261 there was 1,222 people who applied and 15 permits distributed.

For the first year, we have that the probability is

$$Pr(\text{win} \geq 1|m = 1) = 1 - \prod_{i=1}^{1} (1 - p_i) \approx 0.0131$$

or a 1.31% chance of getting a permit, which is about double the probability in the lower bound case.

If we again look at the probability of getting a permit over a 5 years, we get

$$Pr(\text{win} \geq 1|m = 5) = 1 - \prod_{i=1}^{5} (1 - p_i) \approx 0.0632$$

so it is a 6.32% chance of winning at least one permit over 5 years, which is about 6 times as likely compared to the lower bound case. Therefore, we can see the importance of buying bonus points, particularly when repeatedly applying to win a permit.

Overall, these bounds provide a general idea of the ranges of probabilities that are faced when using bonus points. I also include a link here to a Desmos page that has the equations set up, so one can enter the parameters to get the bounds. However, one should note that these bounds assume that everyone starts with no bonus points, while in reality many people have already stock piled many bonus points, so the probabilities presented are likely overestimates of the true probabilities if one were to enter a lottery today.

3 Pros and Cons of the Current Market

In the current market for hunting permits there are places where the market works well and places where it could be improved. For the positives, the market is good in that it is easy to understand the basic mechanisms of how permits are distributed. Since the permits are just chosen by a lottery people can understand how this works. It is also easy for the hunters to participate in because all they need to do is just list their top three locations for the permits to enter the drawings. Another pro of the current system is that it is a generally fair system in the sense that everyone has the same probability of winning (in the case of bonus points, everyone can acquire them as they only cost two dollars when applying for a permit). Overall, the current market has low barriers to participate, which allows everyone interested in hunting to participate.

For the negatives, the nature of the lottery for allocation of permits means that it is entirely up to chance to actually get a permit. This means that there is going to be an inefficient allocation in the sense that people who value the permits the most are not going to necessarily get them. It could be the case that someone who wants to try out hunting for the first time applies for a permit in a highly demanded location and wins it, while the avid hunters who highly value that location miss out on the permits.

Another negative is that there could be permit markets that could generate more revenue for the Montana FWP. There is a lot of demand for for these hunting permits, so the FWP could potentially try other methods that could generate more revenue. This revenue could then be used for conservation efforts for the wildlife in Montana, so maximizing revenue could lead to benefits to the environment.

4 Prior Research on Similar Markets

A similar types of market that has already been studied is the radio spectrum market. This is because the market for radio spectrum essentially sell permits that allow companies to use certain radio spectrum in specified geographical areas, which is similar to how hunting permits works.

In 1994 the Federal Communications Commission (FCC) adopted a simultaneous multi-round auction format to allocation radio spectrum (McMillan, 1994). The FCC decided to have a multi-round auction because it reduces the effect of winner's curse, which is the where the winner of the item is the one who over estimates the true value of the item . In response to potential winners curse, the bidders bid cautiously which is bad for the government because they want to generate lots of revenue by bidders bidding a lot. The multi round auction creates a similar effect as an open auction because bidders are able to get more information by seeing other bids. The government also chose a multi round auction over a normal open auction because it gives the government more control against potential collusion by having it such that the government doesn't publicly reveal the names of the bidders, just the bid amounts.

The government also chose to do a simultaneous auction as opposed to a sequential auction. Sequential auctions are in practice easier to implement because the government just sells the different spectrum blocks one at a time. However, bidders cannot change their bids after learning new information from the later bids, so there is less flexibility in constructing different groups of licenses. Therefore, the government decided to use a simultaneous auction even though it is more complicated.

5 Proposed Improvement

Understanding the auction for radio spectrum, offers insight into thinking of a design choice for a hunting permit market. When choosing an auction format for hunting, it should be widely accessible so everyone is able to participate. Although the multi round auction does offer some good benefits, this would be unreasonable to ask those who want to hunt to spend a large amount of time repeatedly participating in many rounds of bidding, especially when these types of auctions can go on for many months. It would also be immense work to look at the thousands of other bids and try to adjust one's own bid. The market should also make it so bidding one's true value is the optimal bidding strategy. This again makes it easier for people to participate because they don't need to do any special calculations to place their bid. Another nice feature to have in the market would be to have a mechanism that does not impose any payments on those who do not win anything.

With this in mind, I propose getting rid of the lottery system and instead use one of two different implementations of the Vickery-Clark-Groves (VCG) auction. I will get into more details of these properties of the VCG auction in the evaluations of this mechanism in section 6. First, I will describe how a VCG auction works and then discuss the two different versions of the auction afterwords. The setup for the VCG auction is that there is a set of goods $X = \{1, \ldots, K\}$ and a group of n bidders. If bidder i receives a bundle of goods X_i, they get utility

$$u_i(X_i, t_i) = v_i(X_i) - t_i$$

where $v_i : 2^X \to \mathbb{R}^+$ is a function for the bidders value and t_i is the bidder's payment. An allocation of goods $(X_1, X_2, \ldots, X_n)$ such that bidder i receives the bundle of goods X_i and where $X_i \cap X_j = \varnothing$ for all i, j (meaning no good is included in two different bidder's allocated bundles). The VCG auction chooses the optimal allocation X^{VCG} by looking at the bidder's reported values $\hat{v}_1, \ldots, \hat{v}_n$ and choosing the allocation such that

$$X^{VCG} \in \arg\max_{(X_1,\ldots,X_n)} \sum_{i=1}^{n} \hat{v}_i(X_i)$$

(This means that the allocation is chosen such that it maximizes the total welfare.)

Now, payments are determined by the equation:

$$t_i^{VCG} = -\sum_{j \neq i} \hat{v}_j(X_j^{VCG}) + \sum_{j \neq i} \hat{v}_j(X_j^{-i})$$

where $X^{-i} \in \arg\max_{(X_1,\ldots,X_n)} \sum_{j \neq i} \hat{v}_j(X_j)$, meaning that it is the optimal allocation given the reported valuations and when bidder i is not present. These payments are not paying what a bidder value's the item at, but instead they pay the opportunity cost for the units won.

Now, the first version of the applying the VCG for hunting permits, which I will call VCG Version 1, is having a separate VCG auction for each of the different species hunting permits. This means, to be able to participate, all one needs to do is to put down their value for all the different locations of the permits. However, each person can only win 1 permit for each species, meaning that one cannot have a bundle with multiple permits.

This auction adds to the base VCG auction in that there is more than one of each location of permit allocated. This can be interpreted as a set of supplies $\{s_1, s_2, \ldots, s_k\} = S$, where s_j is the supply of good j. We have the additional constraints that

$$|X_{s_j}^{VCG}| \leq j, \quad \forall j$$

where $X_{s_j}^{VCG} = \{s_j \in X^{VCG}\}$, meaning that the number of a specific permit given out in the VCG allocation must be less than the supply of the given permit.

An example of VCG Version 1 is the following:

Suppose there is an auction for deer permits for 3 different locations 1, 2 and 3, with respective supply of permits $s_1 = 2$, $s_2 = 1$, $s_3 = 1$ and there are 3 different hunters Alice, Bob and Carol. Suppose they have the following valuations:

Permit	Supply	Alice(v_A)	Bob(v_B)	Carol(v_C)
1	$s_1 = 2$	12	14	10
2	$s_2 = 1$	10	6	3
3	$s_3 = 1$	5	7	5

By trying different combinations of bundles, the optimal bundle allocation is found with Alice getting a permit for location 2 and Bob getting a permit for location 1 and Carol getting a permit for location 1, with a total welfare of 34. Now for payments, Alice pays

$$t_A = -(14 + 10) + (14 + 10) = 0$$

and Bob pays

$$t_B = -(10 + 10) + (10 + 12) = 2$$

and Carol pays

$$t_C = -(14 + 10) + (12 + 14) = 2$$

It is important to note that people can pay zero for a good even if they win something in this auction, such as Alice in this example.

The second version I propose, which I call VCG Version 2, is the same as the previous auction, except it combines all of the different species auctions into one big auction. This means people now need to place bids not only for each location for each different species of permit, but also on the different bundles for different combinations of permits. However, people still cannot include multiple permits of the same species in a single bundle, which will ensure that a maximum of one permit per species can be acquired. This also keeps the conditions that the total sum of the permits for each location must be less than the set supply.

A simple example of VCG Version 2 is the following:

Suppose there is an auction for permits for deer and elk in locations 1 and 2 with supply of permits $s_{1,\text{deer}} = 1$ and $s_{2,\text{deer}} = 1$ and $s_{1,\text{elk}} = 1$ and $s_{2,\text{elk}} = 1$. Suppose there are two hunters Bob and Alice with the following valuations:

Permit	Supply	Alice(v_A)	Bob(v_B)
Deer_1	1	5	10
Deer_2	1	8	3
Elk_1	1	13	11
Elk_2	1	5	7
$\text{Deer}_1, \text{Elk}_1$	$(1, 1)$	20	21
$\text{Deer}_1, \text{Elk}_2$	$(1, 1)$	15	25
$\text{Deer}_2, \text{Elk}_1$	$(1, 1)$	24	22
$\text{Deer}_2, \text{Elk}_2$	$(1, 1)$	30	25

Here, the optimal allocation is Alice getting the Deer 2 and Elk 2 Bundle, while Bob gets the Deer 1 and Elk 1 bundle, for a total welfare of 51. In calculating the payments, Alice pays

$$t_A = -21 + 25 = 4$$

and Bob pays

$$t_B = -30 + 30 = 0$$

6 Evaluation of Proposed Improvement

Now, I evaluate the pros and cons of the proposed markets. For positives, these VCG auctions have a lot of nice properties (Ausubel et al., 2006). For ease of the participants, these auctions both have the property that the optimal bidding strategy is to bid the true value. This means there is individuals do not have to do any special calculations to place an optimal bid, nor is there worry of an individuals trying to "game the system" with their bids. Another property that is nice for the participants is that losers in the auctions do not have to pay anything. Since the payments are based on opportunity cost, losers in the auctions do not limit anyone else from winning, so their opportunity cost is zero. The VCG auctions also do not limit the participants to a top 3 choice of permit, as in the current lottery, because they are allowed to list their values for every single permit.

Another set of properties is that the auctions have efficient outcomes. This is because by construction the auction selects the welfare maximizing allocation of hunting permits. This is opposed to the current lottery system because the randomness of the lottery means that it does not allocate based on people's values for the hunting permits. However, the VCG Version 2 can find more optimal allocations compared to the VCG Version 1 due to it accounting for compliments and substitutes of the different permits. For example, one could value an elk permit at 8 dollars and a deer permit at 10 dollars. However, they could think that if they are already out hunting with a deer permit, they might also find some elk while out there, so it would be nice to also have an elk permit, so they value the combination of the permits at 20 dollars. This isn't taken into account in the first version because the different combinations of bundles of goods are not included together in the VCG allocation.

Seeing all the positives of the VCG auction, a reasonable question is why this type of auction isn't used in something like the radio spectrum auction. The reason why is that there some drawbacks to using the VCG auction (Leyton-Brown et al., 2017). The first is that these are very hard to solve for in cases with lots of goods and people due to the amount of different combinations of allocations. Solving for optimal allocations and for all the payments can require a lot computational power and in many cases such as the radio spectrum allocation cannot be solved in a reasonable amount of time. There is also a concern for collusion where people can work together to bid low amounts to not have to pay very much. However, in a market with so many people this is not as much of a concern.

Another problem is that it generally leads to low revenue. This can be shown by the example of the VCG Version 1 from earlier, in which Alice did not have to pay anything for her permit which she valued at \$12. However, the current lottery system is already not a particularly high revenue allocation system, so there could be potential for similar if not higher revenue with the VCG mechanisms.

A major issue that the markets I proposed have is that they require more complexity on the part of the the hunters compared to the current lottery because they need to list out the values for each possible permit type. This is also made much worse in the VCG Version 2 due to all the combinations of different species of animals and locations that hunters would have to look at and evaluate how much they value.

Overall, of the VCG mechanisms I proposed, I recommend the Montana FWP to look into VCG Version 1. First, it would need to be evaluated if it is computationally feasible, but if so it has many nice properties. The main reason why it is a better fit than the VCG Version 2 is that the reduced complexity outweighs the potential benefits of taking into account compliments and substitutes of the different permits.

7 Conclusions

The nature of the heterogeneous goods makes it hard to have a simple auction for hunting permits if one wants to have good properties in the auction. The current Montana hunting permit lottery system is overall a functioning market, especially in that it is easy for everyone to participate in. However, the lottery system does not lead to efficient allocations and does not lead to particularly high revenues. Therefore, I propose the use of the VCG Version 1 auction, which creates separate VCG auctions for each species for hunting permits. This allows hunters to simply list what they value the different location hunting permits and then the mechanism chooses a welfare maximizing allocation. This auction, although generally low in terms of revenue, could potentially be higher in revenue than the current lottery system. For future research, there needs to be an investigation into the computational viability and revenues from this proposed auction format.

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