

An Analysis of Strategies in Dominion

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Abstract

In this paper, we introduce an analysis of strategies of a popular board game—Dominion. We focus on what strategies can be a better choice under different game settings. To do this, we look at three classical strategies, which are “Greedy,” “Big-Money,” and “Wait for gold,” along with their updated version by adding action cards and doing simulated experiments running 10000 times by programming in RStudio. We considered the minimum rounds the player needs to end the game with a specific strategy in each one-player setting. In a two-player setting, we compare the number of victory points (the winner will have more victory points) the two players owned after the end of each game by looking at the difference. Since the order of players needs to be considered as well, there are multiple combinations of strategies under analysis.

1. Introduction

• Cards Component

Copper, Silver, and Gold are treasure cards. The number on the above corner represents how many coins the player has. And the number at the lower left corner means how much it costs the player to buy this card.

Estate, Duchy, and Province are cards with different victory points. The more victory points the card represents, the higher it will cost to buy.

There are also ten kinds of action cards. These cards cost players' coins to buy, and each has a special ability to add more enjoyment and flexibility to the game.

All the cards above compose the Supply. Besides, there is a trash mat known as a discard pile.

• Game Rule

Dominion is a deck-building board game. Each player draws an initial hand of 5 cards with 3 Estates and 7 Coppers as starting deck after reshuffling. Then, they build their deck by buying different kinds of cards. There are three phases for each player's turn: action phase, buy phase, and clean-up phase. In the action phase, the player can only play one Action card from his hand but will jump to the next phase if he does not have any action card. Playing an Action card needs the player to announce it and then move it to the "in play" area, which is only for placing action cards. In the buy phase, the player can play any number of Treasure cards in hand to buy any card. Buying a card means moving that card from Supply to the player's discard pile area. When the player enters the clean-up phase, he needs to discard all cards in played card area and hand to discard pile and then reshuffle it. The game ends at the end of a turn if either the province pile is empty, or any three or more Supply piles are empty.

Then we count all the players' victory points, and the player with the most victory points wins the game.

2. Design

2.1 1-player setting

We first consider the strategies independently and test how they perform. Under this setting, we aim to find the minimum rounds when one player can draw out all the province cards ending the game.

2.2 2-player setting

We compare each pair of strategies respectively, along with a swap-order situation, and we will find out which strategy gets the most medals at the end of each game.

3. Experiment without action cards

We first consider the situation when the three strategies do not involve action cards.

3.1 Introduction of Strategies

“Greedy”: In a turn, If the player has coins equal or more than 8, player will buy a Province card, if he/she has coins equal to or more than 6 but less than 8, he/she will buy a Gold. If he/she has coins equal or more than 3 but less than 6, he/she will buy a Silver. Otherwise, no cards will be bought in action phase.

“Big money”: All the conditions are the same as “Greedy,” but the player will buy a Copper if he/she has less than 3 coins instead of buying nothing.

“Wait-for-gold”: All the conditions are the same as “Greedy”, but the player will buy a Province card if he/she has coins equal to or more than 8 and the number of golds in his/her hand is more than a specific number (which we will test out the best one in the following experiments).

3.2 Simulation (Ref. R1 Functions, “Dominion Without action cards.pdf”)

In R, we represent coins—Coppers, Silvers, Gold—as different numbers of medals that they indicate respectively. For example, we represent one Copper as 1 in an array or list, the same for one Silver as 2, and one Gold as 3. We give six parameters for base cards and assign numbers to them, indicating how many of them are at the beginning of a game.

Functions: We define *getcarda*, *getcardb*, *reshuffle* and *buy_greedy*, *buy_bigmoney*, and *buy_waitgold* as six basic functions.

getcarda: indicating the process of drawing cards from the player’s deck, returning a vector called “hand” which shows the cards in the player’s hand.

getcardb: indicating the process of removing cards from the deck.

reshuffle: reshuffle cards in the discard pile when one player’s turn ends. We use *sample* function in R to do this reshuffling.

buy_greedy: this function takes the “greedy” strategy in the action phase for the player and will return a list containing cards the player bought in this turn, which is defined as “*buy_card*”, and return the number of victory points

buy_bigmoney: this function takes the “Big money” strategy in the action phase for the player and will return a list containing cards the player bought in this turn, defined as “*buy_card*”, and return the number of victory points.

buy_waitgold: this function takes the “Wait-for-gold” strategy in the action phase for the player and will return a list containing cards the player bought in this turn, which is defined as “*buy_card*”, and return the number of victory points as well.

4. Results

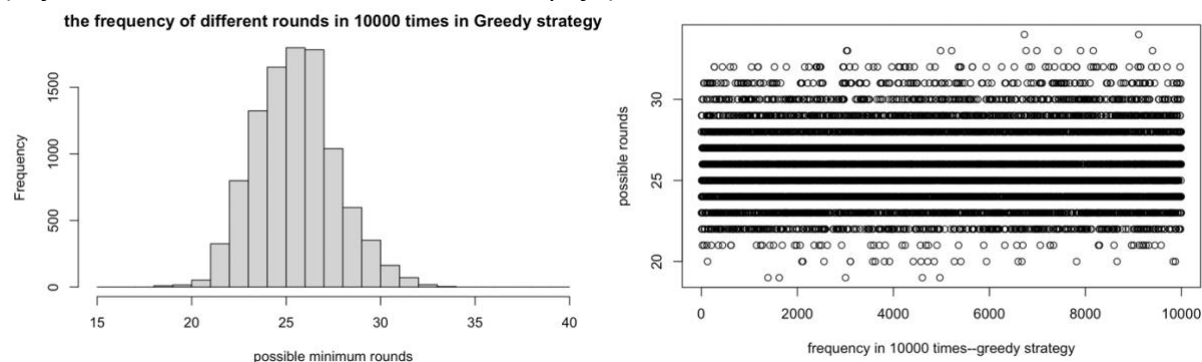
We always have our initial deck defined as (1,1,1,1,1,1,1,0,0,0), 0 represents estate cards that we will not use, and assigning it as 0 can promise it not affect results in our simulation. We use the *for* loop for simulating 10000 times games, the *while* loop is inside *for* loop and is used for simulating players taking turns and recording changes in the number of cards and medal points.

4.1 Dominion without actions cards (Ref. “Dominion Without action cards.pdf”)

one-player setting

“Greedy”

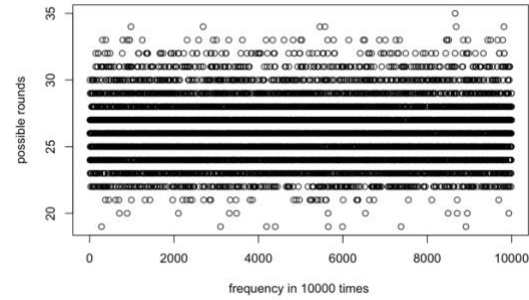
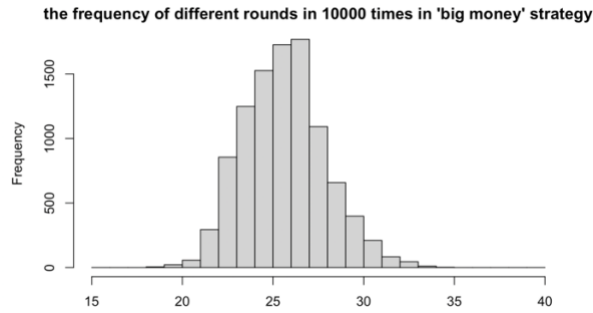
(Ref. R2, “Dominion Without action cards. pdf”)



The results show that the minimum rounds under the “Greedy” strategy will likely happen around 25 rounds. It is unlikely that the game will last after 35 rounds.

“Big money”

(Ref. R3, “Dominion Without action cards. pdf”)



The results show that the minimum rounds under the “Big money” strategy will most likely happen around 26 rounds. Also, there is more likely that the game will end before 26 rounds than the game ends after 26 rounds.

“Wait-for-Gold” (Ref. R4, “Dominion Without action cards. pdf”)

After adjusting parameters x in `buy_waitgold` function (`sum(unlist(all_cards == 3)) >= x`), we got results as,

$x=0$, mean rounds= 25.9747

$x=1$, mean rounds= 25.891

$x=2$, mean rounds= 25.8051

$x=3$, mean rounds= 25.7373

$x=4$, mean rounds= 25.7123, the least.

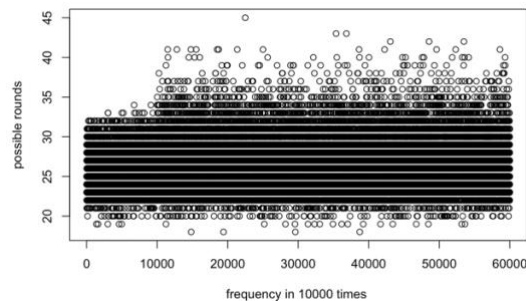
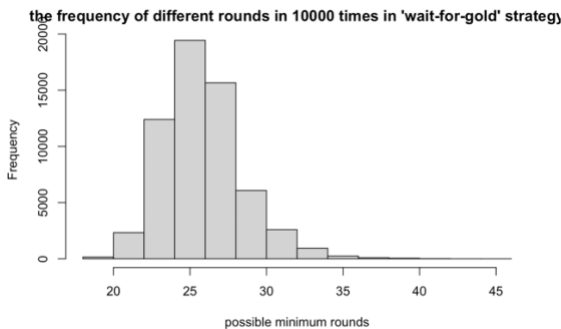
$x=5$, mean rounds= 25.7977

$x=6$, mean rounds= 25.9903

$x=7$, mean rounds= 26.2896

$x=8$, mean rounds= 26.683

Therefore, we choose $x = 4$ as the best one for wait-for-gold strategy.



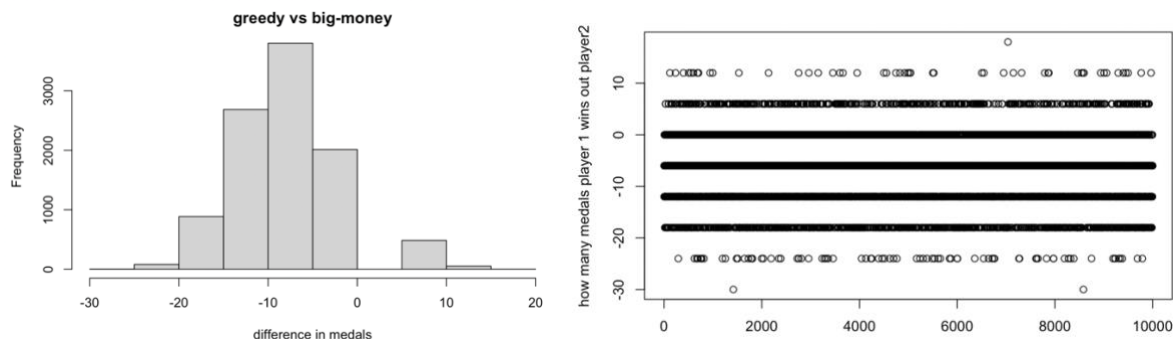
From the results, the most possible minimum number of rounds is 25, but the maximum number of rounds could be 45, which means the “wait for gold” strategy is not a choice as safe as the “Greedy” and the “Big money” for one-player setting.

4.2. Two-player setting

In case of the possibility that the order of the player who starts the first turn affect results, we did experiments with swapping order for each pair of different strategies respectively. In the following experiments, we will always represent the difference in medals as the number of

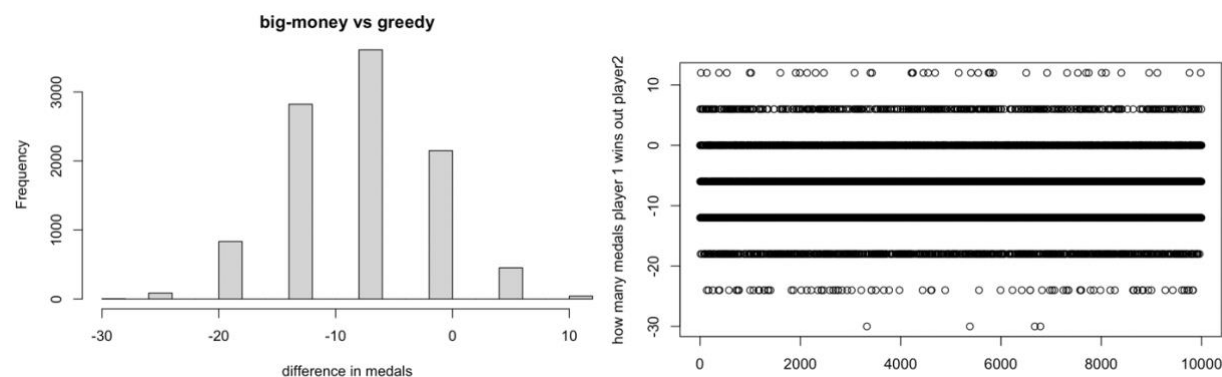
medals from player one minus the number of medals from player two. Therefore, the player who goes first will win if the difference in results is positive, and vice versa.

Player1: “Greedy” strategy vs Player 2: “Big money” strategy (“Greedy” goes first)
(Ref. R5, “Dominion Without action cards. pdf”)



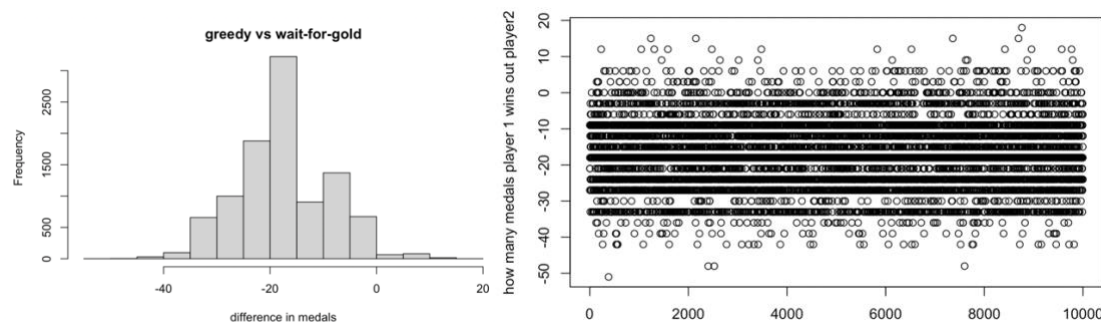
From the plots above, we could conclude that “Big money would be better than greedy strategy.

Player1: “Big money” strategy vs Player 2: “Greedy” strategy (“Big money” going first)
(Ref. R6, “Dominion Without action cards. pdf”)



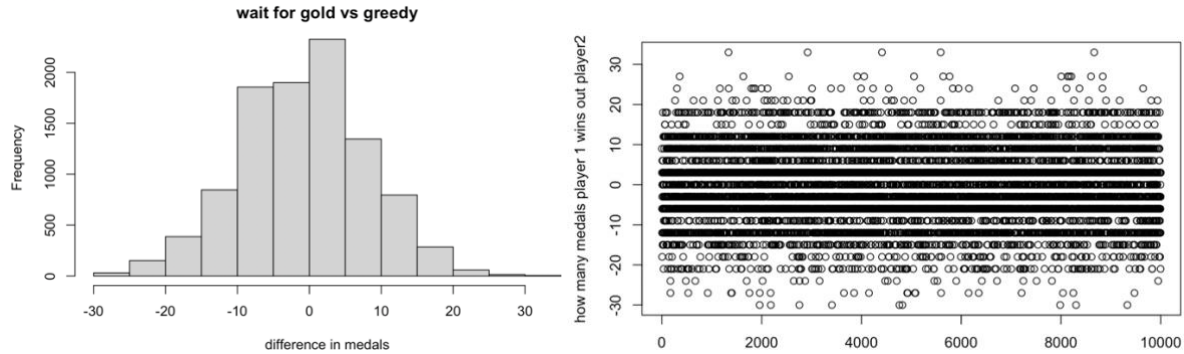
With swapping orders, it looks like the greedy strategy would be better this time.

Player1: “Greedy” strategy vs Player 2: “Wait for gold” strategy (“Greedy” going first)
(Ref. R7, “Dominion Without action cards. pdf”)



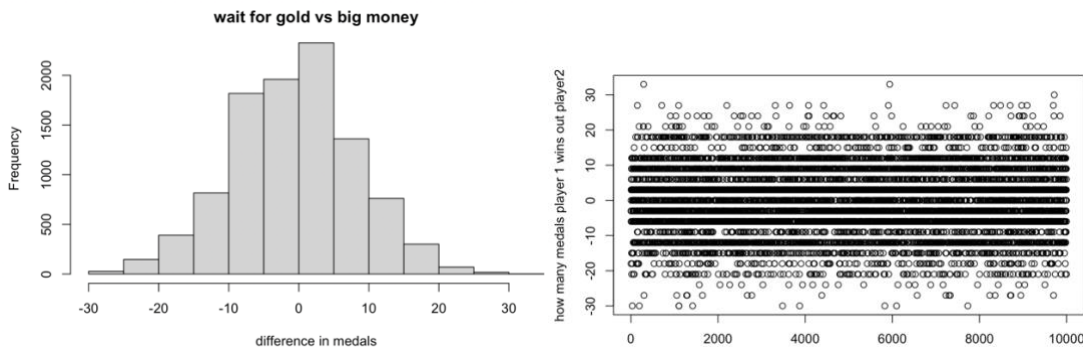
The result shows that the wait-for-gold wins much more victory points at the end than “Greedy”.

Player1: “Wait for gold” strategy vs Player 2: “Greedy” strategy (“Wait for gold” goes first)
(Ref. R8, “Dominion Without action cards. pdf”)



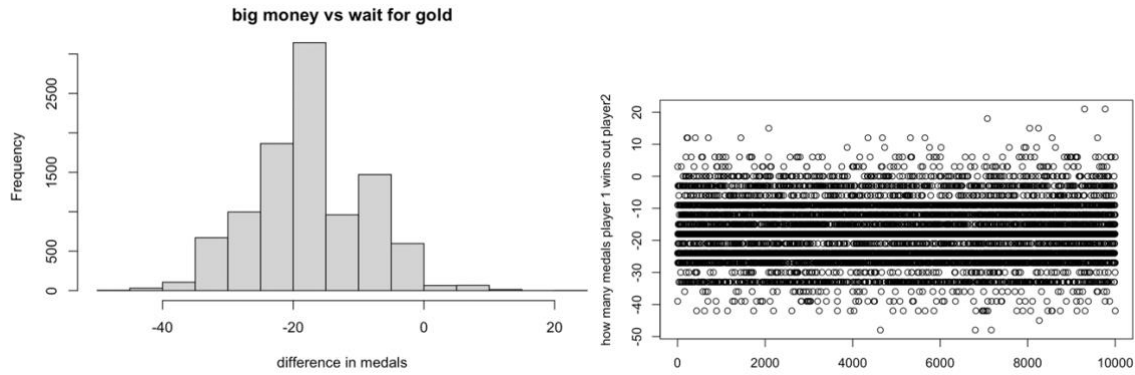
When the “Wait for gold” strategy goes first, we found out that their performance has no obvious difference, though the greedy will win in few more games.

Player1: “Wait for gold” strategy vs Player 2: “Big money” strategy (“Big money” goes first)
(Ref. R9, “Dominion Without action cards. pdf”)



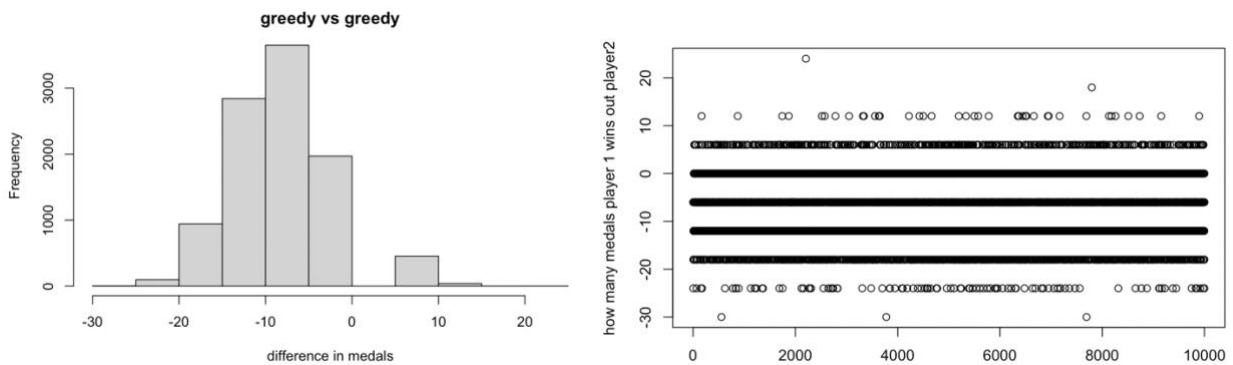
Similar to the previous pairs' results, their performance is not noticeable when the "Wait for gold" strategy goes first, though the "Big money" will win in a few more games.

Player1: “Big money” strategy vs Player 2: “Wait for gold” strategy (“Wait for gold” goes first)
(Ref. R10, “Dominion Without action cards. pdf”)

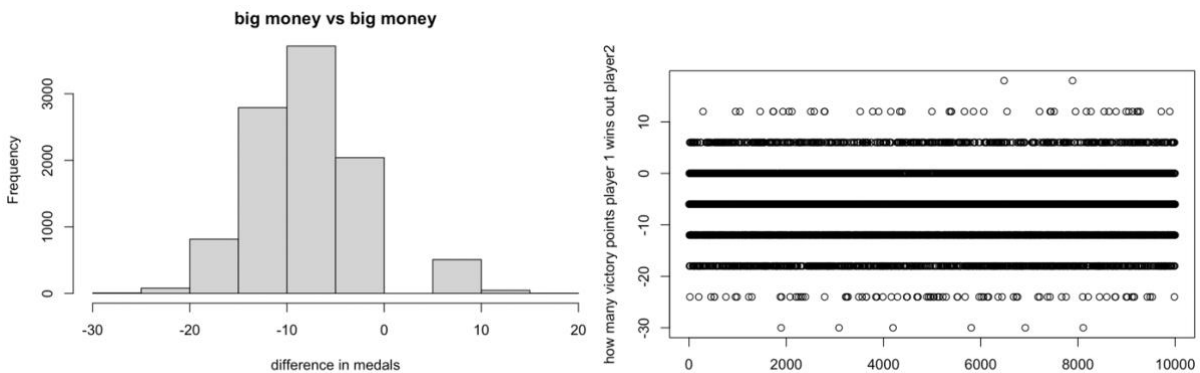


From the plots, in more than 3000 games, the player with “Wait for gold” strategy will win 20 more victory points than the player with “Big money” strategy.

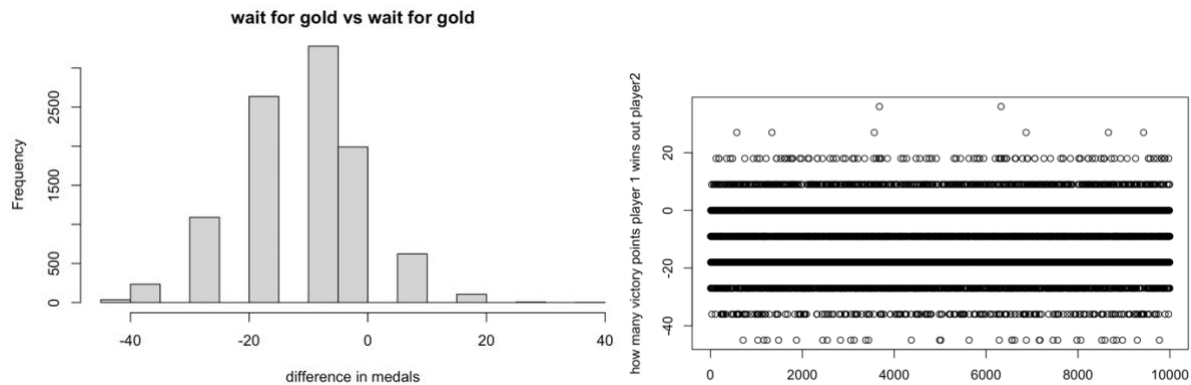
Player1: “Greedy” strategy vs Player 2: “Greedy” strategy (Ref. R11, “Dominion Without action cards. pdf”)



Player1: “Big money” strategy vs Player 2: “Big money” strategy (Ref. R12, “Dominion Without action cards. pdf”)



Player1: “Wait for gold” strategy vs Player 2: “Wait for gold” strategy (Ref. R13, “Dominion Without action cards. pdf”)



4.3 Observation

The three results above show that the order matters in a two-player setting with the same strategies, and the player who goes later always takes advantage. However, suppose the two players take different strategies above. In that case, the "Wait-for-gold" strategy performs better than the others since even the player with the "Wait-for-gold" strategy goes first, which in a less advantaged order, He/she still has close to a 50% chance to win.

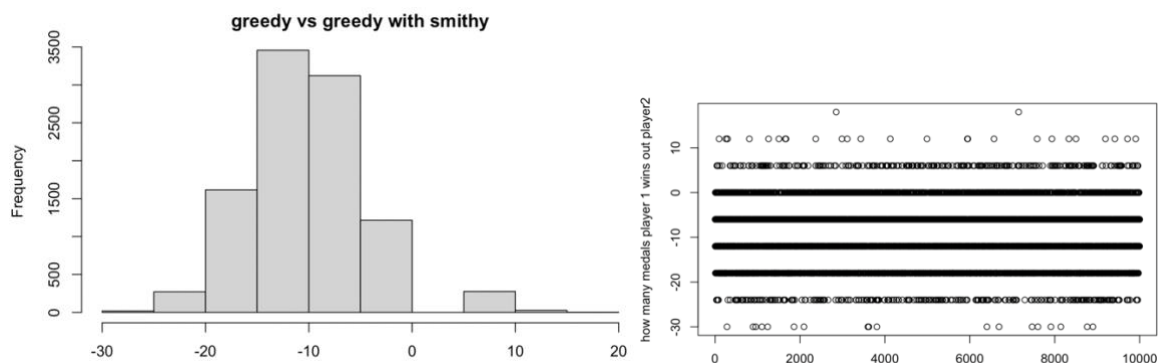
5. Experiments with action cards—Smithy

The Smithy card allows the player to draw three cards from the deck once the player uses it in the action phase. We want to add this card to the three strategies and repeat experiments to see if there is any exciting outcome. However, it is not a wise decision to buy out all the Smithy cards. Through experiments, we found out a limit which is best for the three strategies—the number of five times the total Smithy card (including Smithy cards in hand, deck, and discard pile) needs to be less than the total number of all kinds of cards in hand, deck, and discard pile.

5.1

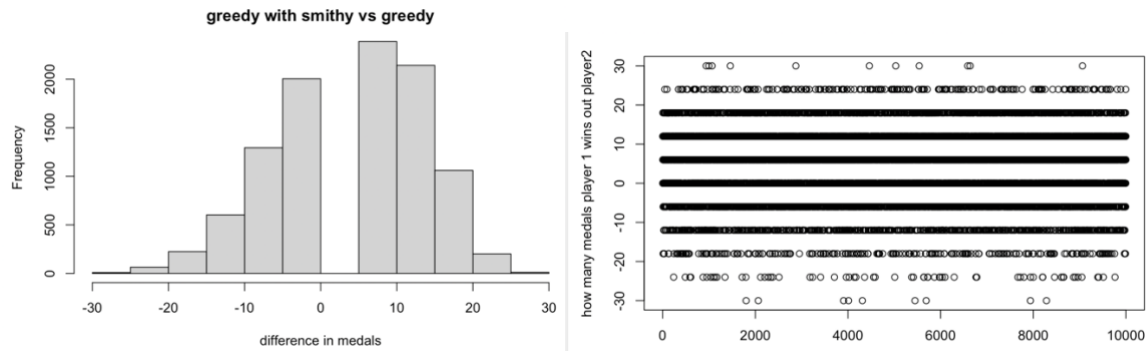
“Greedy” vs “Greedy” with Smithy

(Ref. R2.4, “Dominion with action cards.pdf”)

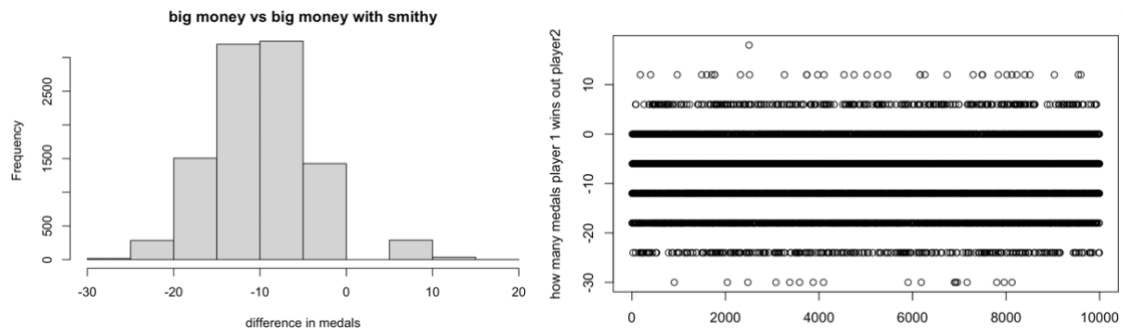


“Greedy” with Smithy vs “Greedy”

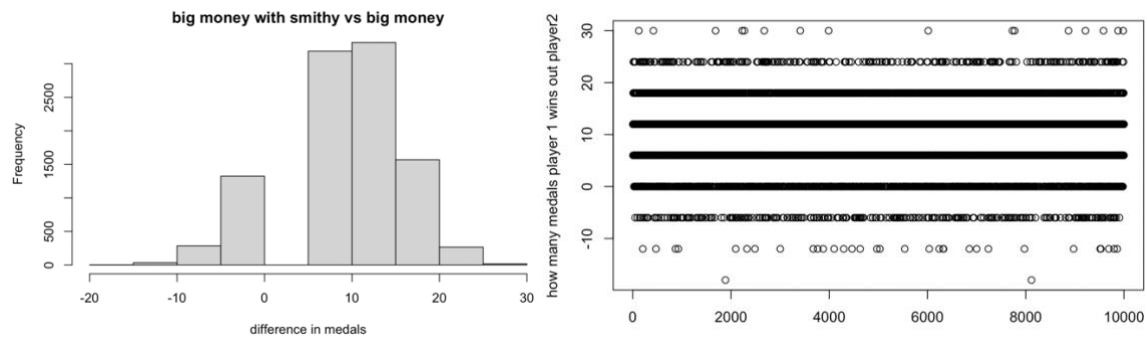
(Ref. R2.5, “Dominion with action cards.pdf”)



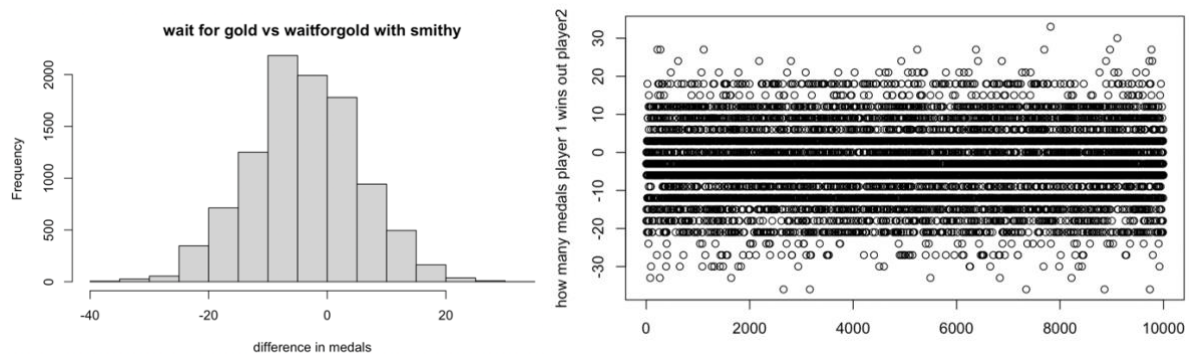
“Big money” vs “Big money” with Smithy
 (Ref. R2.7, “Dominion with action cards.pdf”)



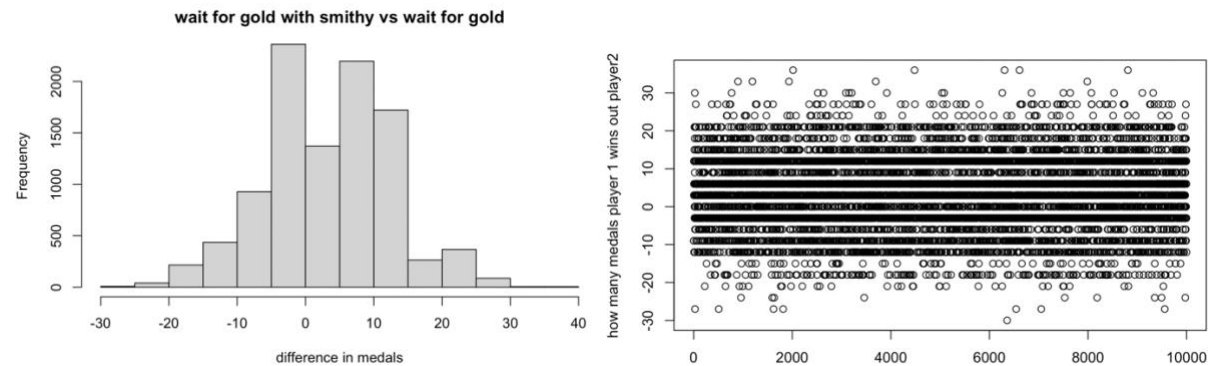
“Big money” with Smithy vs “Big money”
 (Ref. R2.6, “Dominion with action cards.pdf”)



“Wait for gold” vs “Wait for gold” with Smithy
 (Ref. R2.8, “Dominion with action cards.pdf”)



“Wait for gold” with Smithy vs “Wait for gold”
(Ref. R2.9, “Dominion with action cards.pdf”)

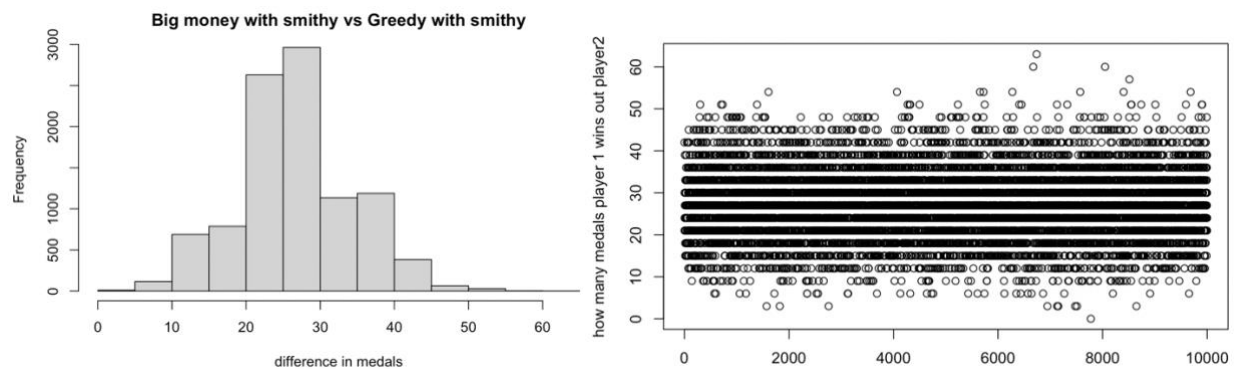


Observation: All three strategies perform better than after adding the Smithy card. So it is reasonable to refer that "Smithy" can improve the original strategies.

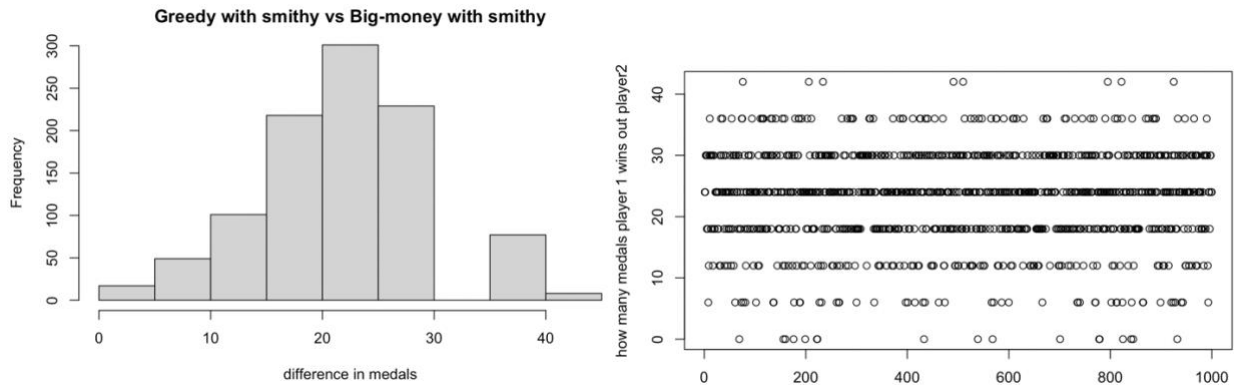
5.2

We then compare all strategies with the “Smithy” card to see which strategy can be improved most by the “Smithy” card.

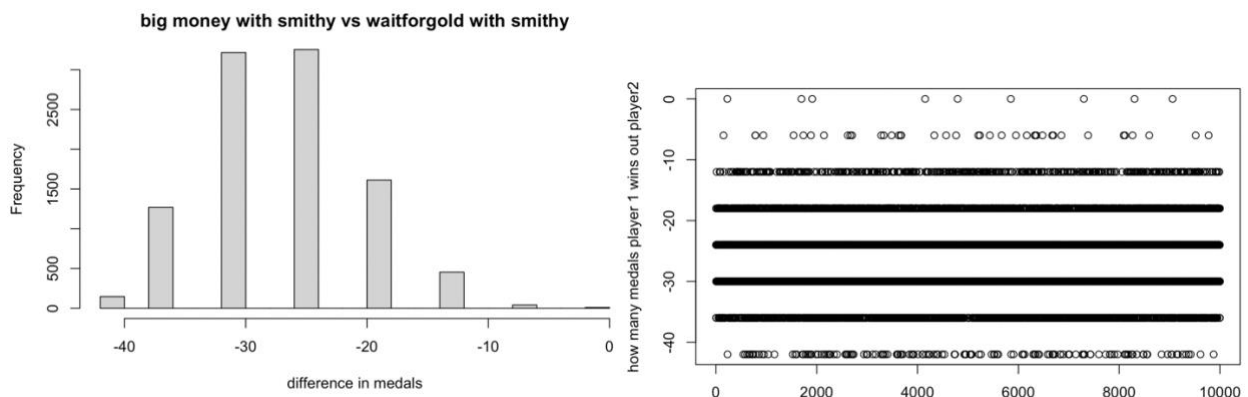
“Big money” with Smithy vs “Greedy” with Smithy
(Ref. R2.13, “Dominion with action cards.pdf”)



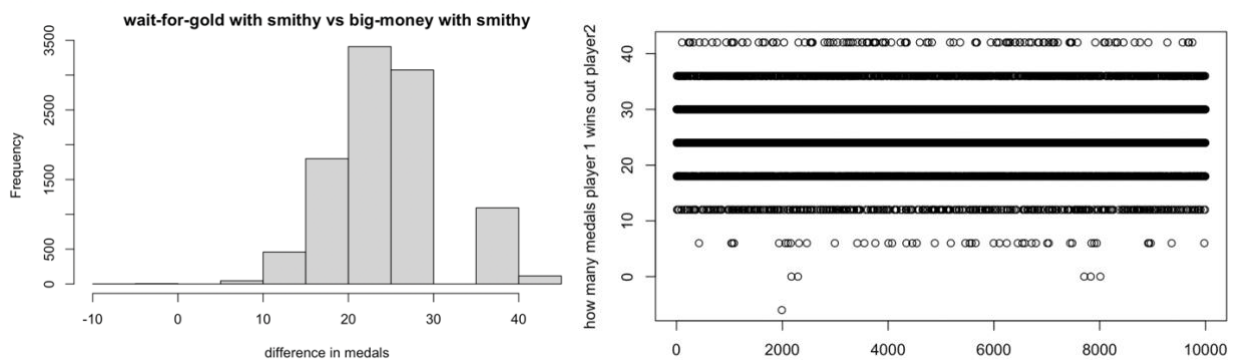
“Greedy” with Smithy vs “Big money” with Smithy
(Ref. R2.14, “Dominion with action cards.pdf”)



“Big money” Smithy vs “Wait for gold” with Smithy
(Ref. R2.18, “Dominion with action cards.pdf”)



“Wait for gold” with Smithy vs “Big money” Smithy
(Ref. R2.17, “Dominion with action cards.pdf”)

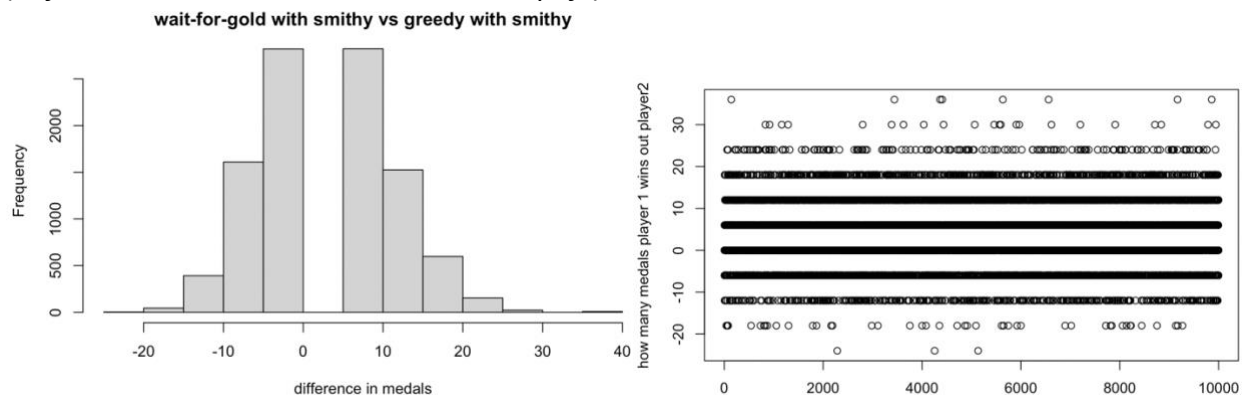


Observation: The order again dominates the results in these two combinations. The player who goes first will always win. Besides, the “Big-money” with Smithy goes first can win with more

victory points than the “Greedy” with Smithy goes first. Next, we choose to compare Wait-for-gold with Smithy and Greedy with Smithy.

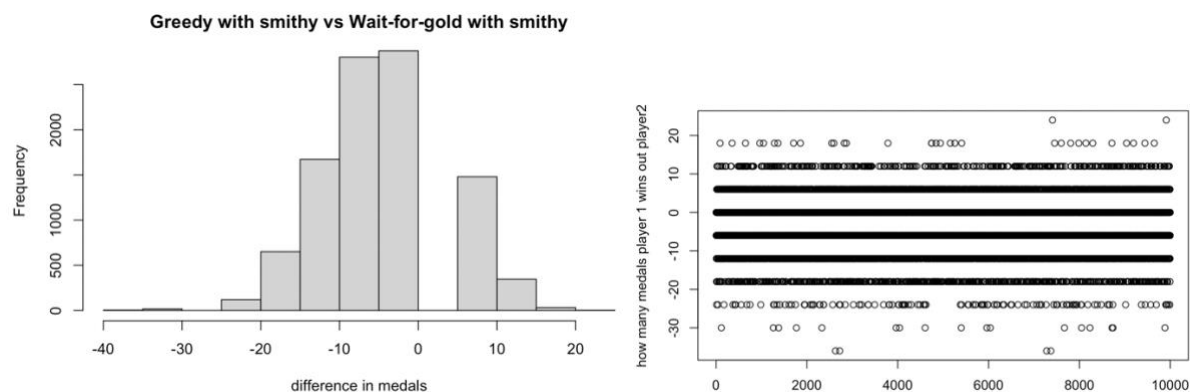
“Wait for gold” with Smithy vs “Greedy” with Smithy

(Ref. R2.15, “Dominion with action cards.pdf”)



“Greedy” with Smithy vs “Wait for gold” with Smithy

(Ref. R2.16, “Dominion with action cards.pdf”)



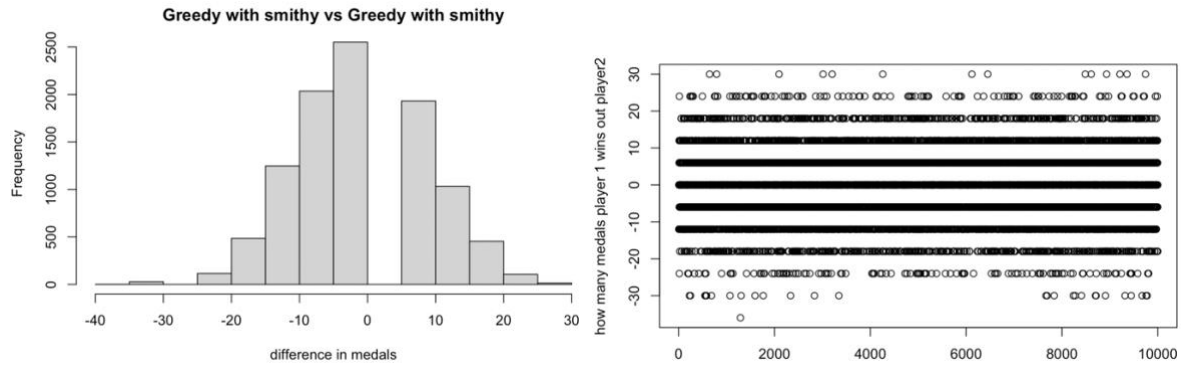
Observation: Surprisingly, the "Wait for gold" strategy with the Smithy card can always win versus the "Greedy" strategy with the Smithy card, no matter the player's order.

5.3 same strategies with “Smithy” card

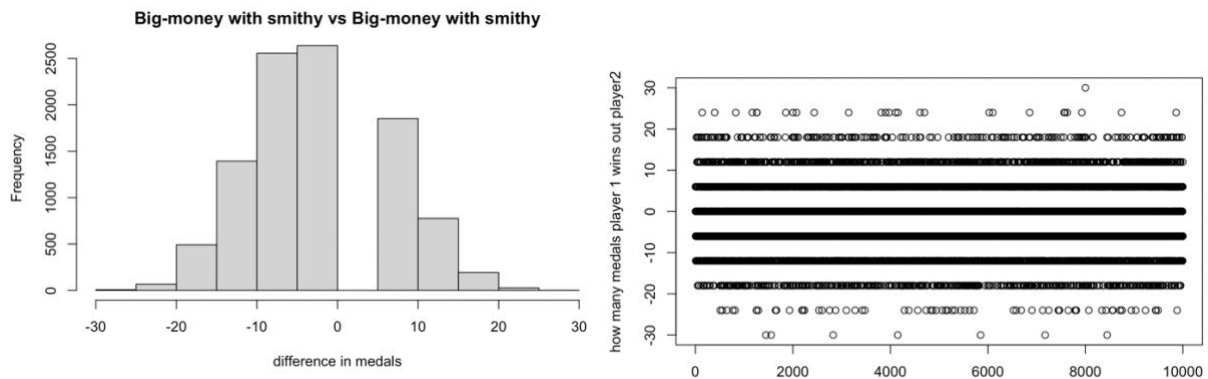
We suppose that the two players all take strategies with the Smithy card.

“Greedy” with Smithy vs “Greedy” with Smithy

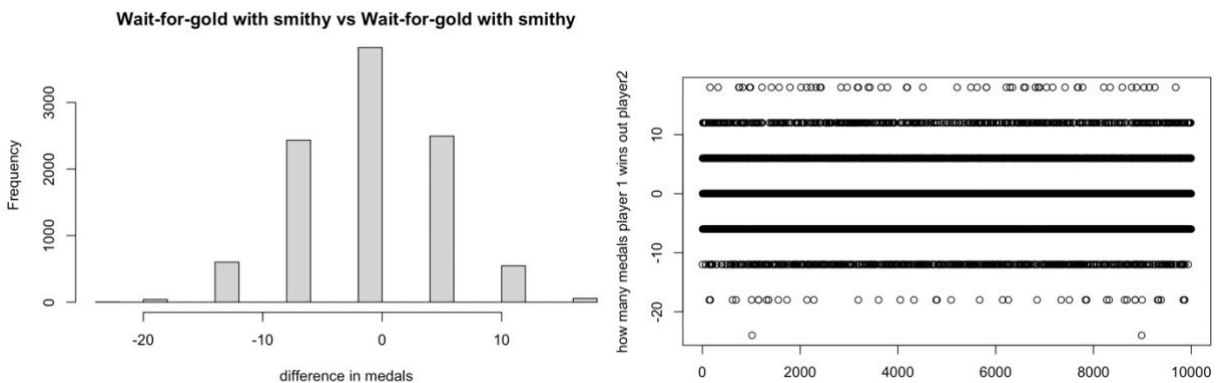
(Ref. R2.11, “Dominion with action cards.pdf”)



“Big money” with Smithy vs “Big money” with Smithy
 (Ref. R2.12, “Dominion with action cards.pdf”)



“Wait for gold” with Smithy vs “Wait for gold” with Smithy
 (Ref. R2.10, “Dominion with action cards.pdf”)



Observation: When the two players take the same strategy with the Smithy card, the player's order still determines the results: the player who goes later will win more victory points.

6. Experiments with action cards—Remodel

Remodel: The player can play this action card when he has a card in his hand except Remodel card to trash. When the player plays this card in the action phase, the player needs to trash a card and then gain a card from the Supply, which costs up to 2 coins more than the card the player trashes.

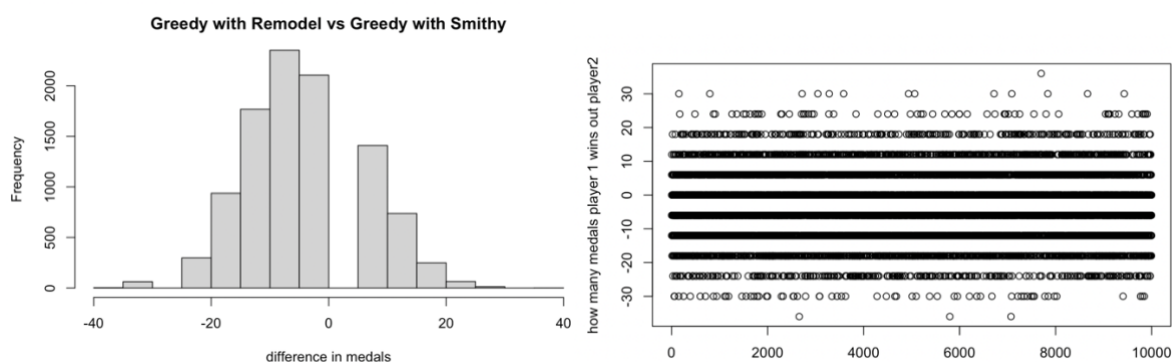
Strategy with Remodel

We are considering using *remodel* card to help the player trash a *gold* and gain a *province* card. It aims to gain the *province* card quickly way. However, we still need to set constraints to use or play this card. First, besides satisfying all conditions to play this card, we add a limit for the number of the *gold* cards from every area, including the *deck*, *hand*, and *discard pile*, to be equal to or larger than 4. If ten times the total number of the *remodel* cards from all cards is larger than the total number of all cards, we don't buy Remodel anymore.

6.1 Experiments

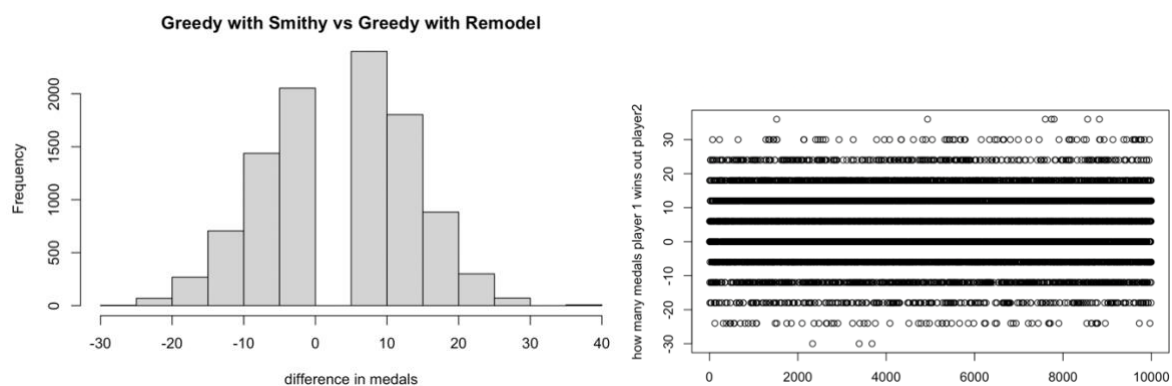
“Greedy” with Remodel vs “Greedy” with Smithy

(Ref. R3.2, “Dominion with action cards.pdf”)



“Greedy” with Smithy vs “Greedy” with Remodel

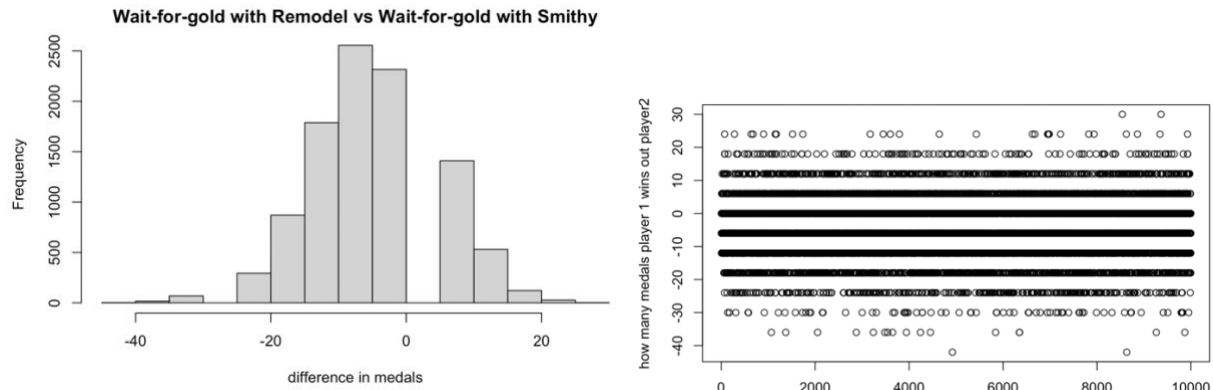
(Ref. R3.3, “Dominion with action cards.pdf”)



Observation: Unlike the “Greedy” strategy with Smithy can always perform better than the “Greedy” strategy, the “Greedy” strategy with Remodel can only win the “Greedy” strategy with Smithy in one of the order situations.

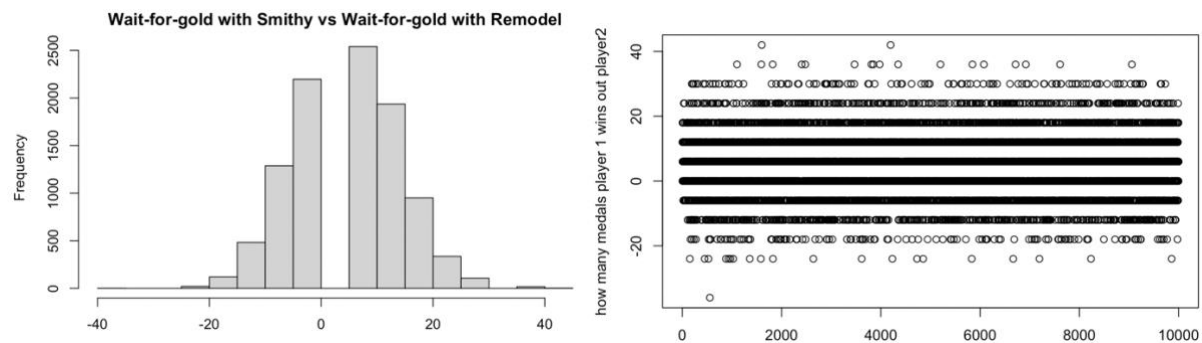
“Wait for gold” with Remodel vs “Wait for gold” with Smithy

(Ref. R3.6, “Dominion with action cards.pdf”)



“Wait for gold” with Smithy vs “Wait for gold” with Remodel

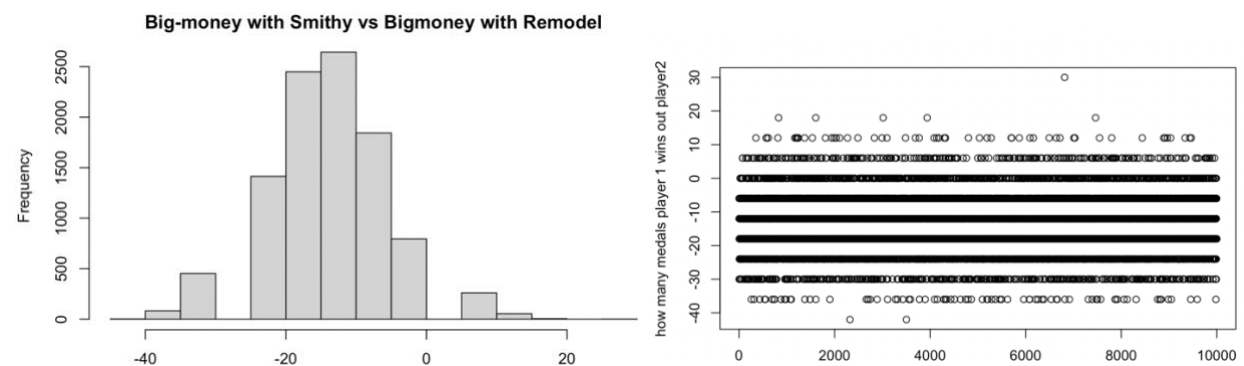
(Ref. R3.7, “Dominion with action cards.pdf”)



Observation: Unlike the “Wait for gold” strategy with Smithy can always perform better than the “Wait for gold” strategy, the “Wait for gold” strategy with Remodel can only win the “Wait for gold” strategy with Smithy in one of the order situations.

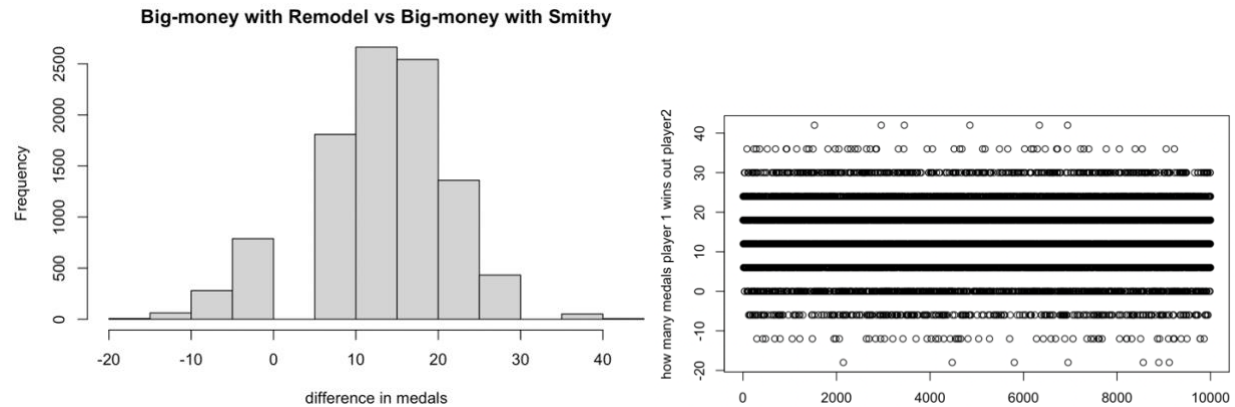
“Big money” with Smithy vs “Big money” with Remodel

(Ref. R3.4, “Dominion with action cards.pdf”)



“Big money” with Remodel vs “Big money” with Smithy

(Ref. R3.5, “Dominion with action cards.pdf”)

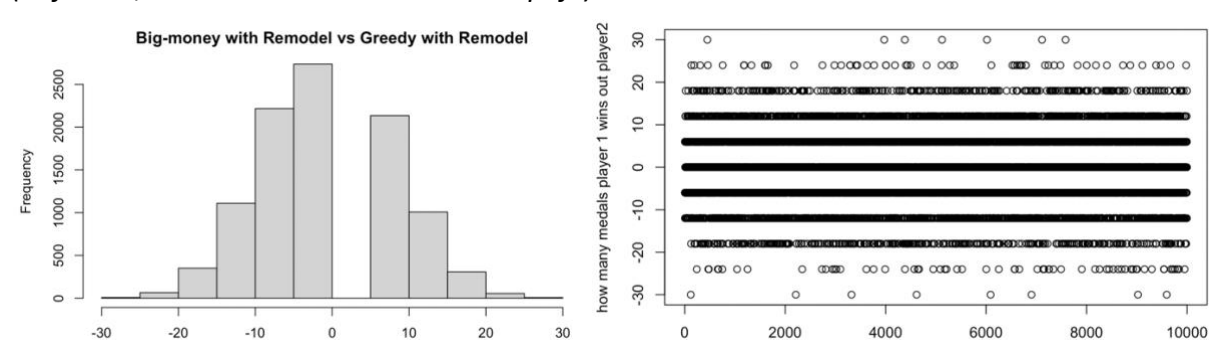


Observation: We found out that the “Big money” strategy with Remodel can always perform better than the “Big money” with Smithy. So we can infer that Remodel card is more powerful than Smithy card to improve the “Big money” strategy.

Now, let us see which strategies can be best after adding Remodel.

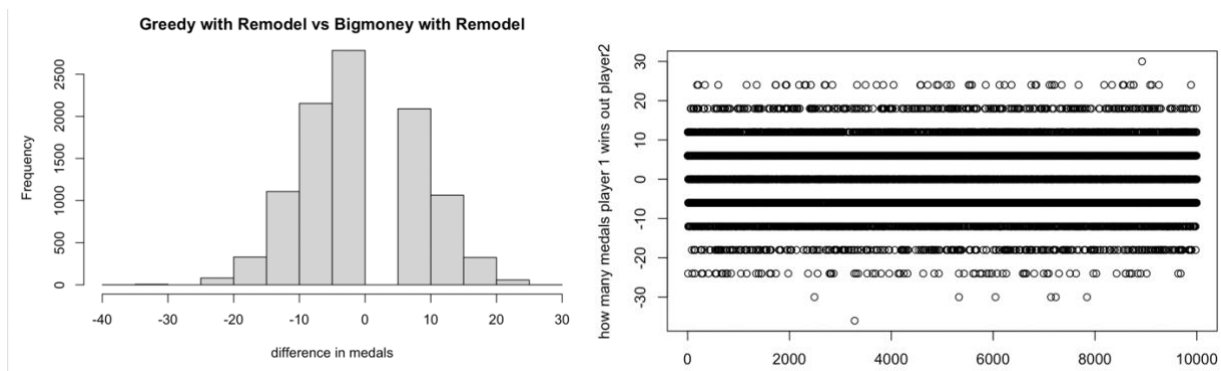
“Big money” with Remodel vs “Greedy” with Remodel

(Ref. R3.8, “Dominion with action cards.pdf”)

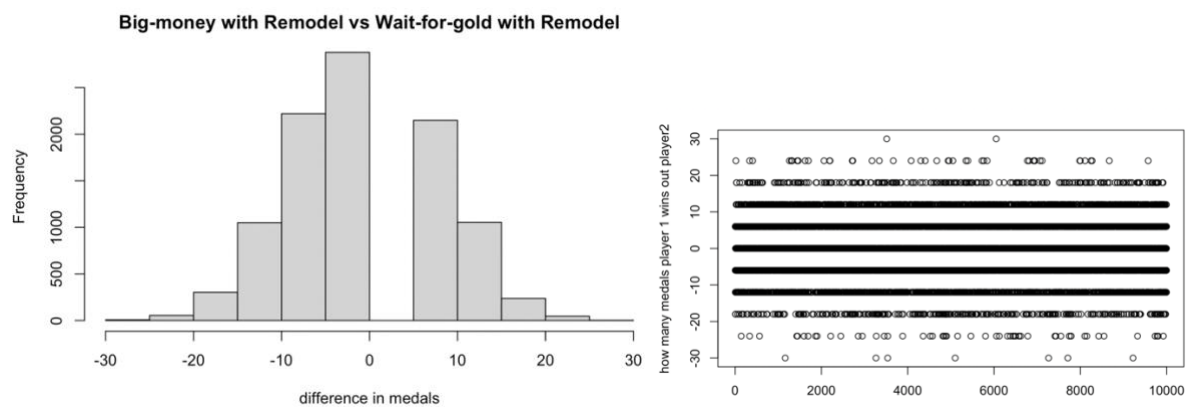


“Greedy” with Remodel vs “Big money” with Remodel

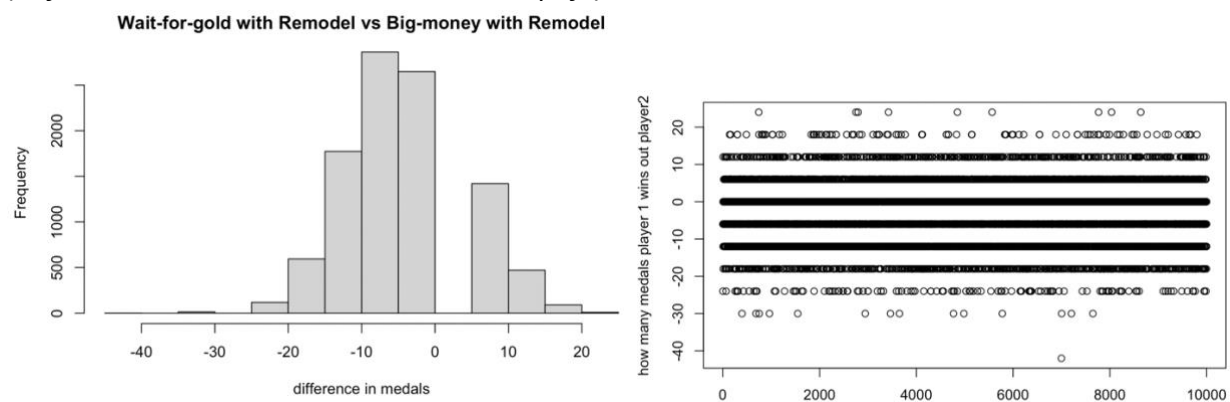
(Ref. R3.9, “Dominion with action cards.pdf”)



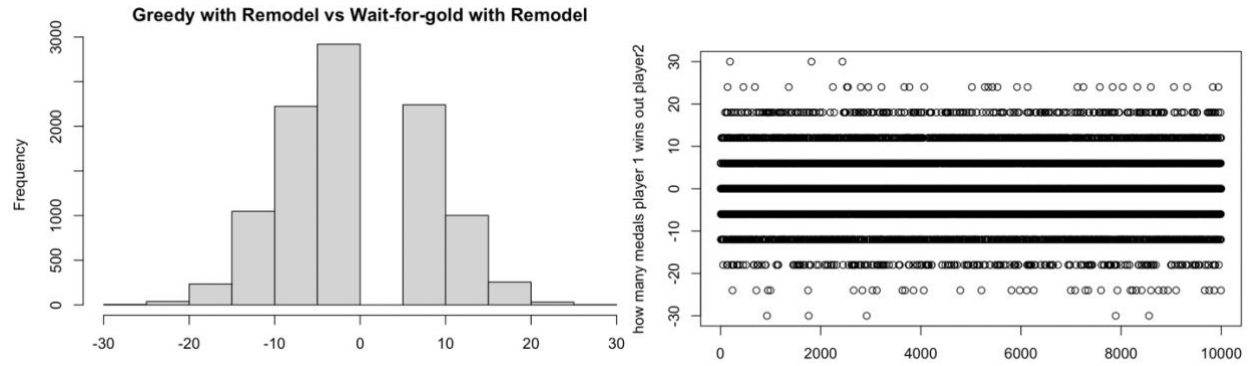
“Big money” with Remodel vs “Wait for gold” with Remodel
 (Ref. R3.10, “Dominion with action cards.pdf”)



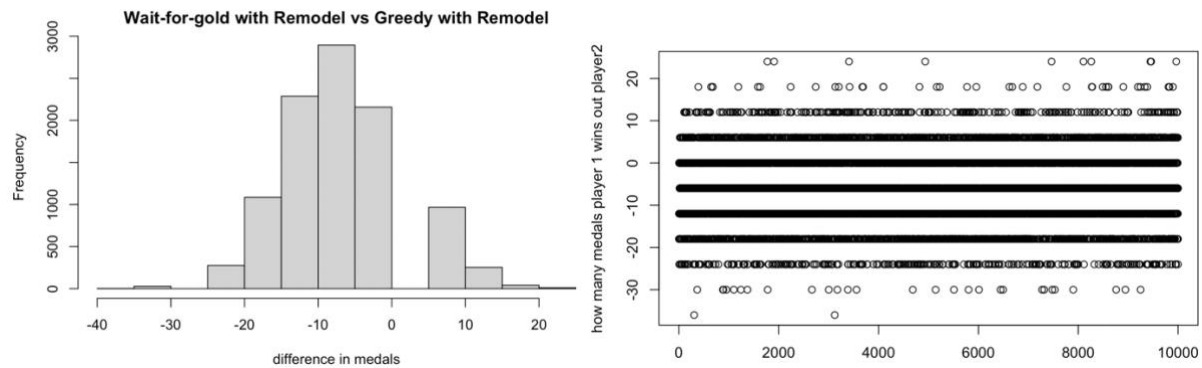
“Wait for gold” with Remodel vs “Big money” with Remodel
 (Ref. R3.11, “Dominion with action cards.pdf”)



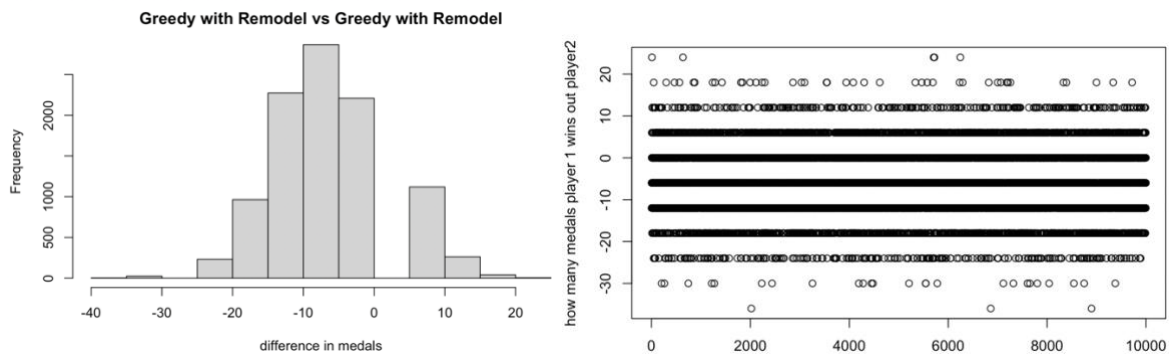
“Greedy” with Remodel vs “Wait for gold” with Remodel
 (Ref. R3.12, “Dominion with action cards.pdf”)



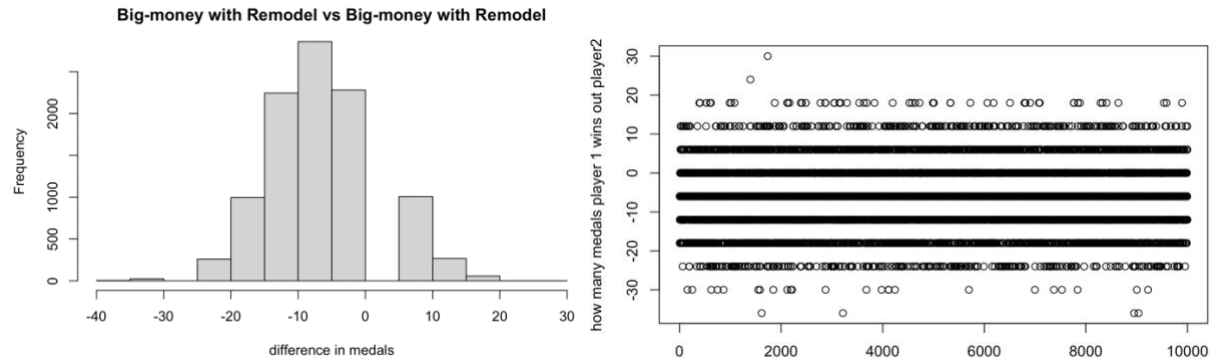
“Wait for gold” with Remodel vs “Greedy” with Remodel (Ref. R3.13, “Dominion with action cards.pdf”)



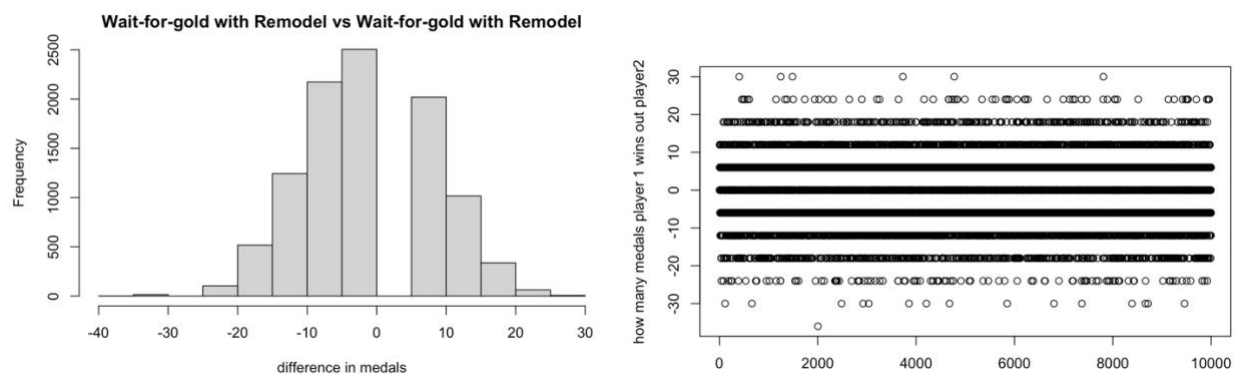
“Greedy” with Remodel vs “Greedy” with Remodel (Ref. R3.14, “Dominion with action cards.pdf”)



“Big money” with Remodel vs “Big money” with Remodel (Ref. R3.15, “Dominion with action cards.pdf”)



“Wait for gold” with Remodel vs “Wait for gold” with Remodel (Ref. R3.16, “Dominion with action cards.pdf”)



Observation: If the two players all take strategies with Remodel, the result would still be dominated by the order of the players.

7. Conclusion

We select three strategies to analyze by building functions according to each step in the real game process. Then we simulate the game experiments in different settings by comparing every possible pair of strategies. Through all the experiments we did, the player could have a better understanding of the three strategies, “Greedy,” “Big-money,” and “wait-for-gold,” before they take one of them as their choice. Without action cards involved, the results show that the order of the player plays a dominant role—the player goes later and always wins the game with more victory points. It is an exciting result since we assumed the results would be that one of the strategies would perform better than the two others. With the “Smithy” card joining in, the winning condition differs. The “Smithy” card improves the three strategies, which means it is always better to choose Strategies with Smithy than without. When the players take strategies with Smithy, the results follow the rule of order we found previously, except in one situation, which is the “Wait-for-gold” strategy with Smithy always performs better than the “Greedy” strategy with Smithy. Next, we consider another kind of action card which is Remodel. Interestingly, the remodel can only improve the “Big money” strategy to perform better than Smithy. For the other two strategies, Smithy and Remodel will help them win under the rule of

order. Moreover, when the two players take strategies with Remodel, the player who goes later will always win the game.

The research shed light on how the strategies perform in the dominion game. There are many exciting strategies that could be analyzed in the future. For example, a game has ten action cards, including Smithy and Remodel. We could analyze them individually to see if they will improve or weaken the original strategies. What's more, we can combine different strategies to see how that will change the result. Also, the game can have most eight players, and it is a question if the strategies can perform differently as the number of players in a game change.