Winning Camel Up

Mckenzie West

Work by Matt Derksen, Kyle Ecklund, and Matt Gilbert
The Basics

Players bid on Camels as they race around a track.

The player with the most money at the end wins.

Camels move 1-3 spaces, depending on the color and number of the die rolled.
What is a Round?

There are 6 total dice:

• 1 of each of the 5 colors
• 1 gray die
• Each die has sides 1,1,2,2,3,3

After 5 dice have been randomly rolled the round ends and the camel positions are assessed.
What’s the Trick?

• Camels Stack!
On Your Turn

Roll
- Move the camels

Bid
- Winner of the round
- First to the finish line
- Camel in last at game end

Place Tile
- Affect the movement
Board Setup
Randomly Roll and Place

- Randomly select and roll the color dice.
- Place the color camels as their die comes up.
- Randomly roll the gray die. Place black and white camels in the reverse direction.
How Many Starting Positions are There?

Lemma: The number of patterns, ignoring color is\[7!\over 5! 2! = 28.\]

Proof Idea: “Stars and Bars”
That is, arrange 5 *’s and 2 |’s.

Select what 7 spots will be *’s, the remaining 2 will be |’s.
Research Results
Main Research Question

I’m the first player at the start of the game, what should I do?

1. If I roll, then I’m guaranteed 1 coin.

2. If I bet on the camel that wins the round, then I get 5 coins!

3. If the camel I bet on gets 2nd, then I get 1 coin.

4. If the camel I bet on gets 3rd, 4th, or 5th, then I lose a coin.
Answer

Well, it depends on the situation!

In these cases, I bet on green!
Quality of Bets

• Let
  • \( P(1) \) = probability that camel is in the lead at the end of the round,
  • \( P(2) \) = probability the camel is in second at the end of the round, and
  • \( P(3,4,5) = 1 - P(1) - P(2) \).

• The expected value of a bet is:
  \[
  5P(1) + P(2) - P(3,4,5).
  \]

• I will choose the highest expected value.
### Data by Starting Position

<table>
<thead>
<tr>
<th>Starting Position</th>
<th>Expected Value of Bet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.96</td>
</tr>
<tr>
<td>2</td>
<td>0.44600</td>
</tr>
<tr>
<td>3</td>
<td>0.12600</td>
</tr>
<tr>
<td>4</td>
<td>0.77800</td>
</tr>
<tr>
<td>5</td>
<td>-0.31000</td>
</tr>
</tbody>
</table>

2-1-2 Starting Position

<table>
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<tr>
<th>Starting Position</th>
<th>Expected Value of Bet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.72502</td>
</tr>
<tr>
<td>2</td>
<td>1.64095</td>
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<tr>
<td>3</td>
<td>0.91098</td>
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<tr>
<td>4</td>
<td>0.09594</td>
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<tr>
<td>5</td>
<td>-0.37290</td>
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</tbody>
</table>

4-0-1 Starting Position

Computed using simulations with Python!
## Data by Starting Position

<table>
<thead>
<tr>
<th>Starting Position</th>
<th>Expected Value of Bet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.21200</td>
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<tr>
<td>2</td>
<td>0.00200</td>
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<tr>
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<td>1.58000</td>
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<tr>
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<td>5</td>
<td>-0.28200</td>
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### 0-3-2 Starting Position

- Computed using simulations with Python!

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<th>Expected Value of Bet</th>
</tr>
</thead>
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<tr>
<td>2</td>
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<tr>
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<td>1.20552</td>
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<tr>
<td>5</td>
<td>-0.16270</td>
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</table>

### 2-2-1 Starting Position

- Computed using simulations with Python!
Future Directions
What More can we do?

• Create a tool to input game state and output play.
• Can we compute probabilities without simulation?
• What happens after turn 1?
• How many turns on average do games take?
• When should I bet on overall winner/loser?