# Heuristic analysis

**custom_score_3**
This simple heuristic is based on the distance between player location to the board's center. The higher the distance, the lower the score player gets. Because player often gets more legal moves when at the center of the board than when near the board's border.

**custom_score_2**
This heuristic is the combination of open_move heuristic and the distance to the board's center heuristic (custom_score_3). While the custom_score_3 is useful at the early game, the open_move heuristic is the direct way to measure the player's number of legal moves. The combination is useful in case that there are 2 or more moves have the same score (using open_move heuristic). In these cases, player should move to a position closer to the center. To avoid the situation that the distance_to_center heuristic (custom_score_3) over influences the final score, we normalize the distance_to_center score by divide it by the sum of board's width and height to ensure that distance_to_center score always less than 1.

**custom_score**
This heuristic is similar to custom_score_2 but instead of using open_move heuristic, it uses improve_score heuristic. While moving to a position that gives player more move choices is good, moving to a position that gives player more move choices than opponent is even better. After all, the goal of the game is to last longer than the opponent. The combination with distance_to_center heuristic helps improve the early game.

**Tournament result**

| Match # | Opponent | AB_Improved | | AB_Custom | | AB_Custom_2 | | AB_Custom_3 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Won | Lost | Won | Lost | Won | Lost | Won | Lost |
| 1 | Random | 8 | 2 | 10 | 0 | 10 | 0 | 10 | 0 |
| 2 | MM_Open | 7 | 3 | 8 | 2 | 9 | 1 | 6 | 4 |
| 3 | MM_Center | 9 | 1 | 9 | 1 | 8 | 2 | 10 | 0 |
| 4 | MM_Improved | 8 | 2 | 10 | 0 | 5 | 5 | 7 | 3 |
| 5 | AB_Open | 6 | 4 | 5 | 5 | 6 | 4 | 5 | 5 |
| 6 | AB_Center | 6 | 4 | 6 | 4 | 6 | 4 | 5 | 5 |
| 7 | AB_Improved | 4 | 6 | 4 | 6 | 6 | 4 | 4 | 6 |
| | Win Rate: | 68.6% | | 74.3% | | 71.4% | | 67.1% | |

| Match # | Opponent | AB_Custom | | AB_Custom_2 | |
|---|---|---|---|---|---|
| | | Won | Lost | Won | Lost |
| 1 | AB_Improved | 30 | 20 | 24 | 26 |
| | Win Rate: | 60.0% | | 48.0% | |

**Conclusion**
The tournament result shows that the best heuristic of all 3 custom score functions is "custom_score" for its best win rate. All three heuristics are easy to compute. The "custom_score" and is more sensible in assessing the game situation than "custom_score_2" and "custom_score_3". In "custom_score" heuristic, we have to compute the number of legals move 2 times, while for "custom_score_2" heuristic, we only have to compute the number of legals move only one time. But, the difference in computation costs is trivia compares to the computation cost to explore new nodes when we go deep along the game tree. So the average depths of the "custom_score" and "custom_score_2" should be similar.