

DELFT UNIVERSITY OF TECHNOLOGY

IN4010 PRACTICAL ASSIGNMENT 2

Agent assessment and improvement

Group 11:

Hidde COEHOORN

Ralf NIEUWENHUIZEN

Jan-Willem VAN VELZEN

Supervisor:

Reyhan AYDOGAN

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1 Test Description

After finishing the first version of our own negotiation agent, we were provided with the negotiation agents of other groups and their domains. We decided to do a comprehensive set of tests in the genius Tournament environment. 10 Tournaments were ran, for every opponent-profile combination of three parties per tournament, resulting in $2^3 = 8$ sessions per tournament. All opponents were tested in their own domain, with the following exceptions:

- Opponent 9 was not tested, because we were unable to get the agent running.
- Opponent 10 was tested on the domain of Opponent 12, because the domain of Opponent 10 was missing.

We were unable to determine which domain, provided by Opponent 2, was the cooperative, moderate and competitive domain, so we made the alphabetical assumption of *Dinner*, *Sporthal* and *Politics* respectively. The reason for only testing the opponents in their own domain, was because this was the domain they optimized for. This means that an increase in our utility and the social welfare in these domains are more valuable than the other domains.

We also note that sessions were only counted when an agreement was reached as shown in Figure 1 and 2. This resulted in less data for Opponent 2, 6, 7 and 10, specifically for the variables: Distance to Pareto, Distance to Nash, Social Welfare, and the Utilities.

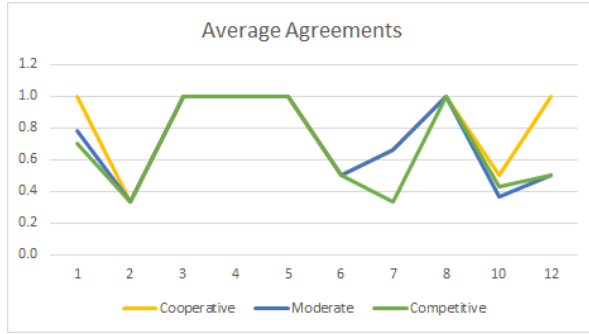


Figure 1: 18 Rounds per Opponent

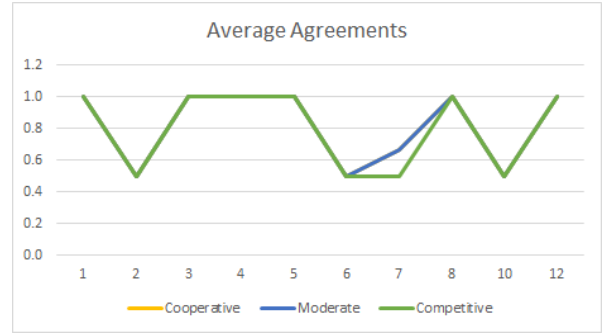


Figure 2: 180 Rounds per Opponent

These tests were done twice, for both 18 and 180 maximal tournament rounds. All results were then averaged over all sessions and domain types, ignoring the sessions with the following agent composition: n/n/n and 11/11/11. All these combined test resulted in a dataset of a whopping $(60 \cdot 30 \cdot 2 =)$ 3600 sessions.

2 Test results

After performing the described tests we ended up with quite a lot of data. The various test results are summarized in figures, some of which are included further on in this chapter to illustrate interesting and valuable observations.

2.1 Agreements

Looking at the Average test agreements in Figure 1 and 2, we see that with a tighter deadline, we achieve less agreements compared to the scenario with a 180-round cap.

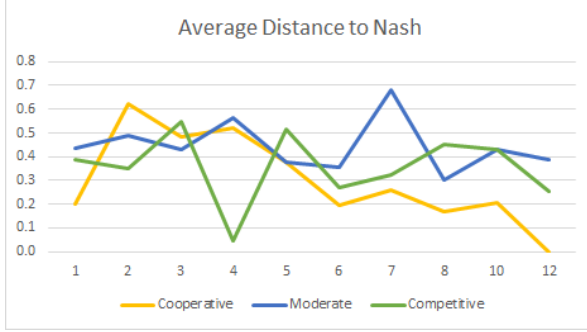


Figure 3: 18 Rounds per Opponent

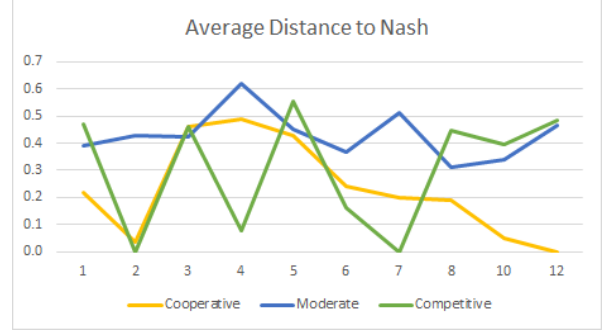


Figure 4: 180 Rounds per Opponent

2.2 Distances to Nash and Pareto

Figures 3 and 4 show the average distance to Nash for each set of tournaments. We see that on the longer negotiations, bids with a lower distance to Nash are found and used. This results in lower distances to Nash. The same can be observed from the average distance to Pareto in Figure 5 and 6.

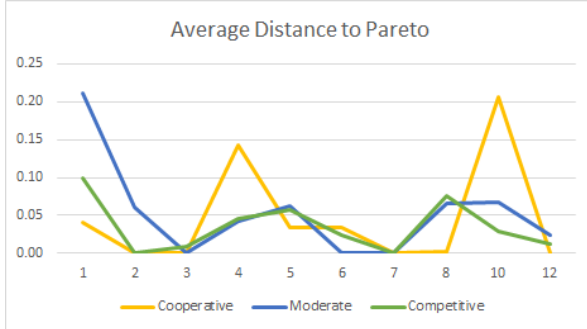


Figure 5: 18 Rounds per Opponent

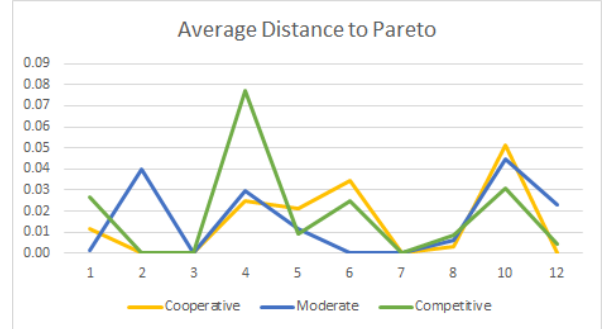


Figure 6: 180 Rounds per Opponent

2.3 Number of Rounds

The number of rounds it takes to reach an agreement (Figure 7 and 8) is relatively the same for both 18- and 180-capped sessions. It can also be observed that the opponents that we reach a lower amount of agreements with, generally take more rounds to that agreement.

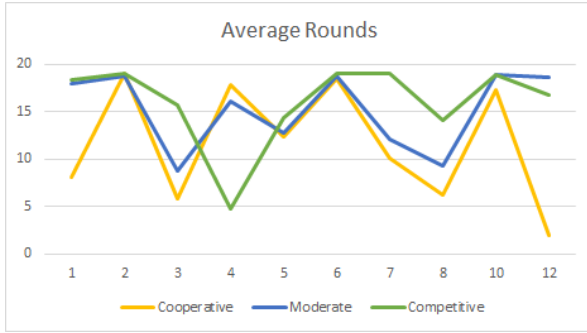


Figure 7: 18 Rounds per Opponent

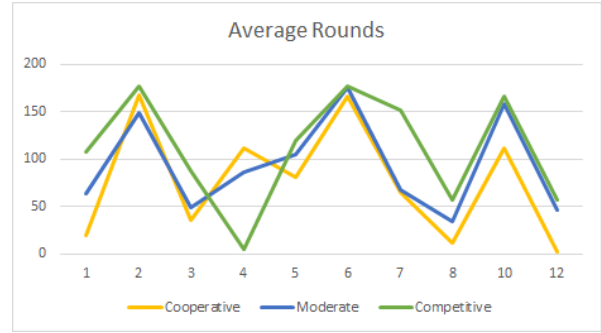


Figure 8: 180 Rounds per Opponent

2.4 Social Welfare

Despite the bigger distances to Nash and Pareto, Figure 9 and 10 show that the average Social Welfare for both short and long negotiations are practically identical.

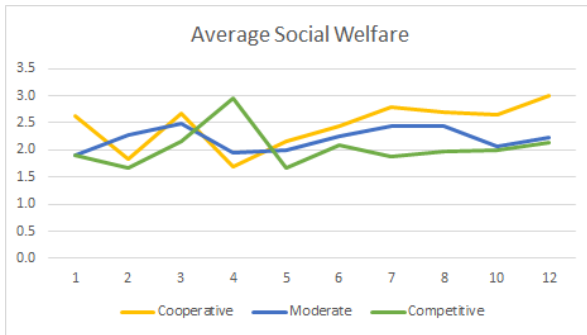


Figure 9: 18 Rounds per Opponent

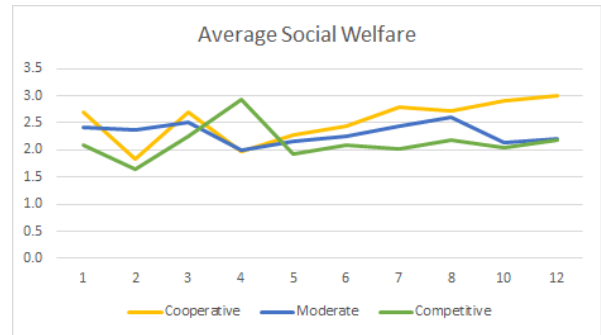


Figure 10: 180 Rounds per Opponent

2.5 Cooperative utilities

Finally we take a look at the achieved utilities. Starting with cooperative in Figure 11 and 12, we perform less in the long negotiation compared to the short negotiation. On average we perform equal to our opponents in the short negotiations, where we are clearly outperformed in the long run.

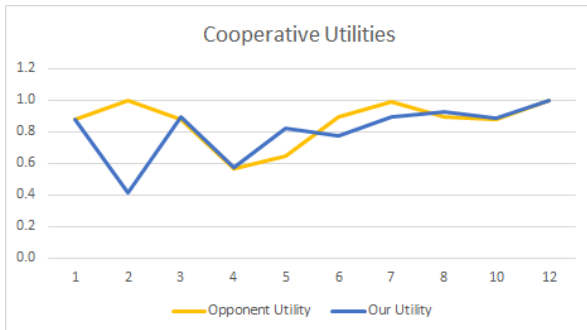


Figure 11: 18 Rounds per Opponent

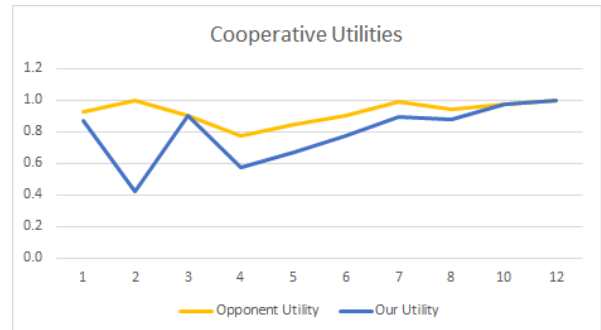


Figure 12: 180 Rounds per Opponent

2.6 Moderate utilities

Secondly the utilities from the moderate domain, shown in Figure 13 and 14. Again, these are mostly equal, with the exception of Opponent 5 outperforming us and Opponent 12 performing less (in the long negotiations).

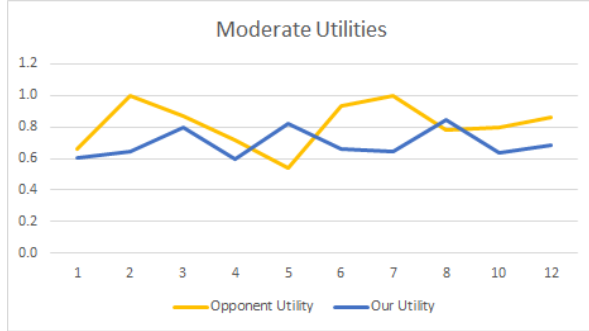


Figure 13: 18 Rounds per Opponent

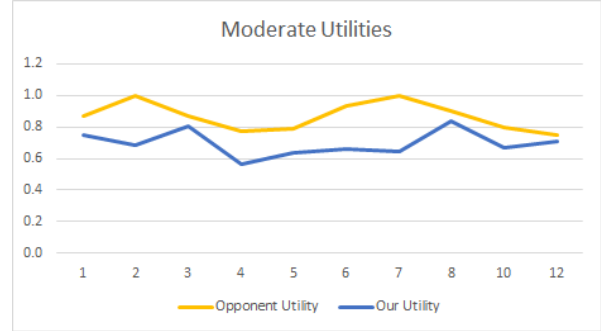


Figure 14: 180 Rounds per Opponent

2.7 Competitive utilities

Without trying to sound too repetitive, looking at the competitive utilities in Figure 15 and 16, we see again that opponent 5 and 12 seem to have the same behavior when comparing the short and long negotiations, with our own performance being less in the long term.

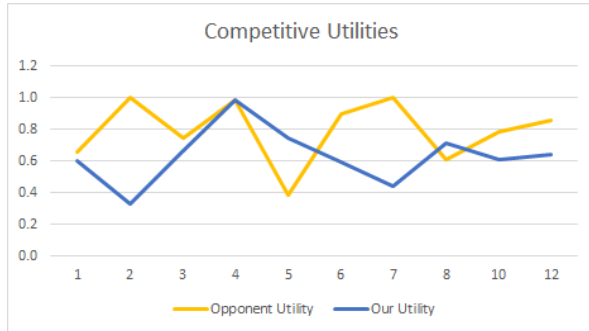


Figure 15: 18 Rounds per Opponent

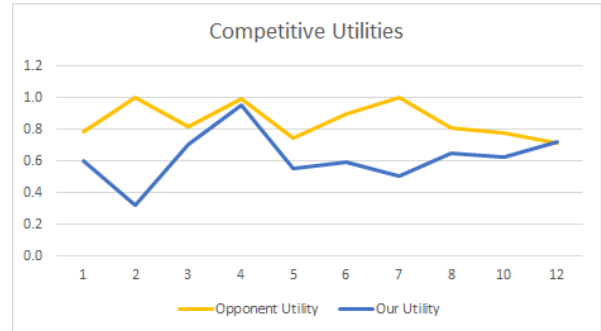


Figure 16: 180 Rounds per Opponent

3 Adaptations

Considering the test results, certain improvements should be made to the agent, to improve the results against other agents.

3.1 Parameter changes

Based on the first version of the agent, there are several adaptations that can be made. Simple changes are the altering of parameters, mostly numerical values, that determine when and how fast actions are taken by the agent. Examples are in the list below.

- The `ReservationValue` starts decreasing automatically after a certain amount of time. In the first version this happened at 85% of time. This can be increased to be less sensitive to the opponent's preferences. It can also be decreased to be more sensitive.
- If the previous bid has been accepted by enough other agents, the `ReservationValue` is also decreased. This currently happens by a multiplication by 0.8. Increasing this value towards 1 will make the agent less sensitive to the opponent's preferences. Decreasing it towards 0 will make it more tolerant.
- When there is no time to create a trusted opponent model, the `GiveIn` tactic is used. This creates a more tolerant offer each round. The amount of tolerance added each round can be adjusted.
- *numberOfRoundsForOpponentModel*. This parameter determines the border between a short negotiation and a long negotiation. We can play around with it to see what gives the best opponent model.

3.2 Strategy changes

Apart from the parameter changes, the bidding and accepting strategy of the agent can also be modified. Below is a list of some of these possible changes. We have however decided, after testing the agent with the parameter changes, not to implement these, as the changes were already satisfying.

- Introduce an "AcceptanceValue" that represents a value above which the agent will always accept. Currently this is partly represented by the `ReservationValue`, but that is not what the `ReservationValue` is meant for.
- Do not bluntly accept after 95% of the time has passed when the `GIVEIN` strategy is used, but instead try to make a reasonable offer around the reservation value.
- A smart determination can be made about when the opponent model is good enough, instead of a fixed limit.

3.3 Actual changes

The changes that were eventually implemented in the new version of the agent are only parameter changes. These values make the agent less sensitive to the opponent's preferences, so less tolerant.

- Changed the time after which the `ReservationValue` starts decreasing automatically from 85% to 95%.

- Changed the multiplier by which the ReservationValue is multiplied if the previous bid has been accepted by enough other agents from 0.8 to 0.9.
- In the GIVEIN tactic, the amount of giving in is changed from the ReservationValue (ranging from 0.95 to 0.6) to 0.975.
- The amount of rounds needed for a trusted opponent model is changed from 20 to 50, so more negotiations are considered short, as this strategy slightly outperforms the strategy of long negotiations.

4 Adaptation results

After implementing the parameter changes described in Section 3 we ran the comprehensive test of 3600 sessions again, with the *differences* in the results showing the following graphs.

4.1 Difference in Amount of Agreements

Looking at Figure 17 and 18, we see that the short negotiations are less likely to end in an agreement. In contrast to the long negotiations, where there is no observable difference. This is very likely the result of our now less sensitive parameters.

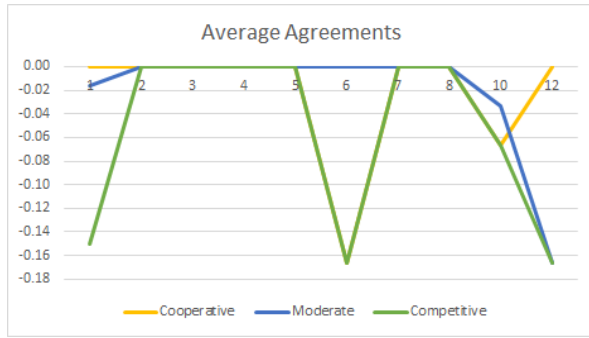


Figure 17: 18 Rounds per Opponent

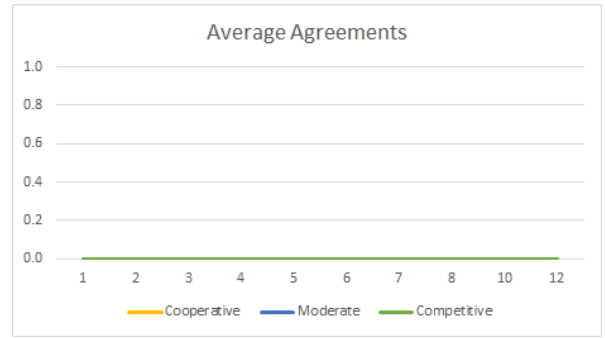


Figure 18: 180 Rounds per Opponent

4.2 Difference in Distances to Nash and Pareto

Seen from Figure 19 20, 21 and 22, we see a little fluctuation around the 0-axis, with the occasional spike. The overall trend is a lower distance, with the exception of Opponent 7. This opponent has bigger distances in the shorter negotiations. These results indicate a slightly better negotiation strategy after the changes made.

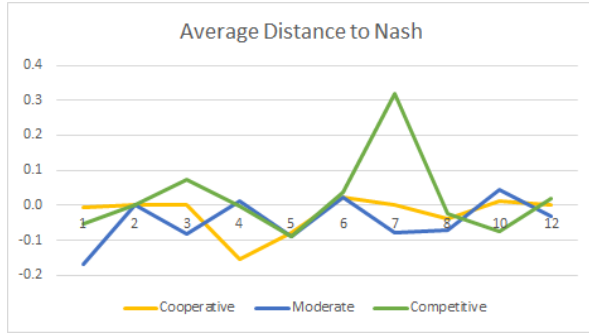


Figure 19: 18 Rounds per Opponent

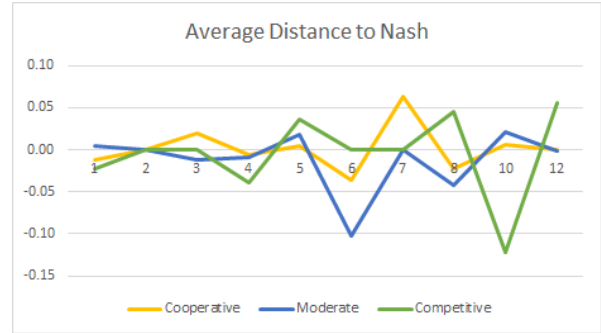


Figure 20: 180 Rounds per Opponent

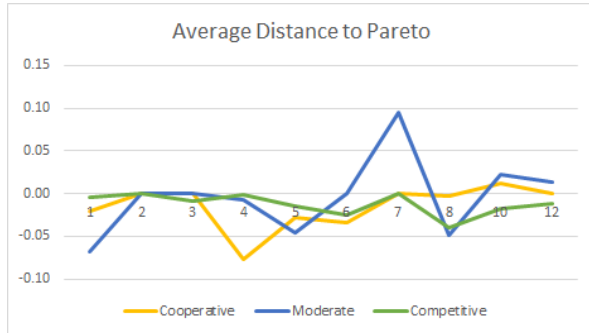


Figure 21: 18 Rounds per Opponent

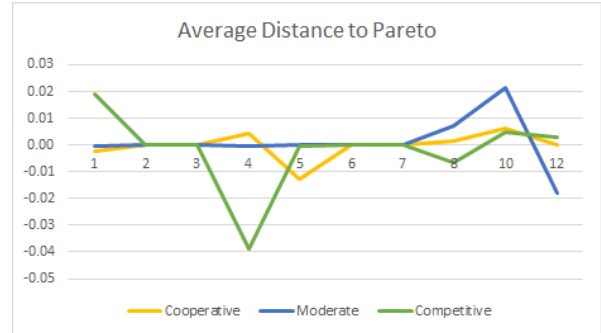


Figure 22: 180 Rounds per Opponent

4.3 Difference in Social Welfare

Figure 23 and 24 show good news all around for the differences in Social Welfare! With the small exception for Opponent 7 in the short negotiations and opponent 10 in the long negotiations, we see a significant positive change in social welfare after the made changes.

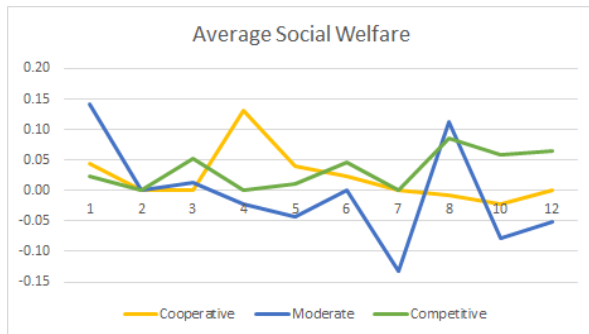


Figure 23: 18 Rounds per Opponent

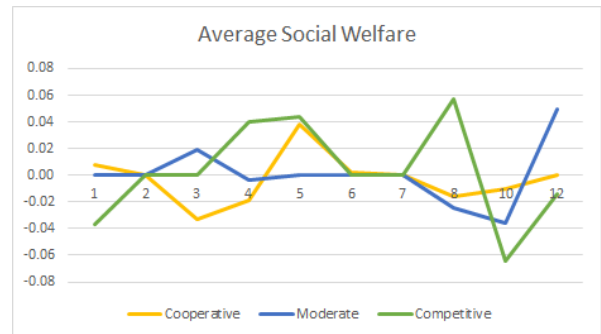


Figure 24: 180 Rounds per Opponent

4.4 Difference in Cooperative Utilities

As shown in Figure 25 and 26, it is clear that there is a significant improvement in our utilities for the cooperative domain.

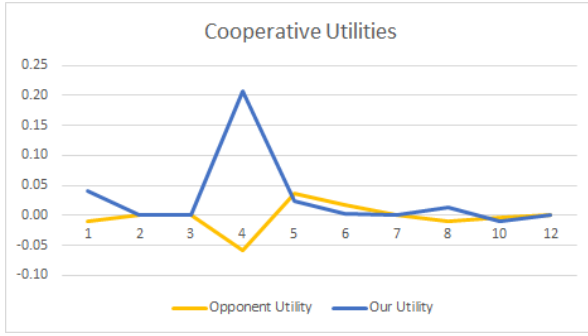


Figure 25: 18 Rounds per Opponent

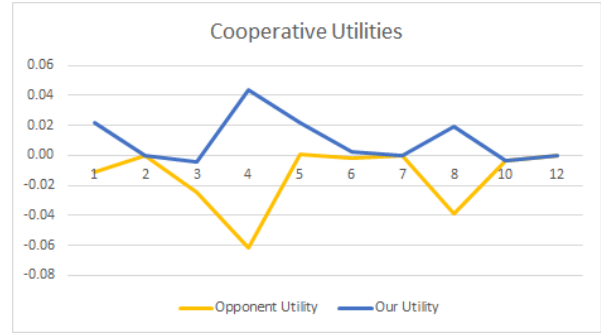


Figure 26: 180 Rounds per Opponent

4.5 Difference in Moderate Utilities

Figure 27 and 28 also show a significant improvement in our performance for the moderate domain.

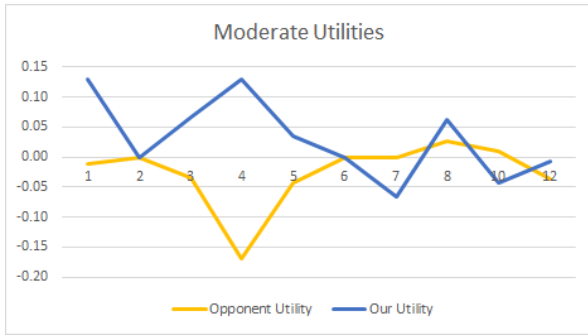


Figure 27: 18 Rounds per Opponent

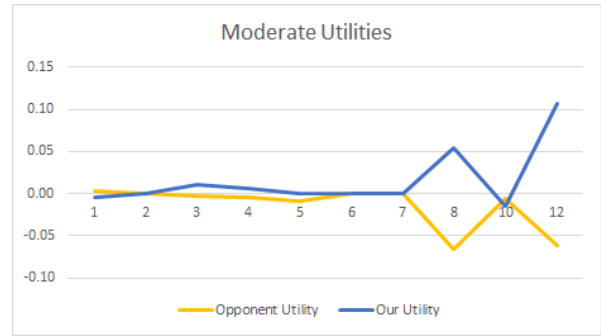


Figure 28: 180 Rounds per Opponent

4.6 Difference in Competitive Utilities

Lastly, for the competitive domain, Figure 29 and 30 also show a significant improvement in our final average utility.

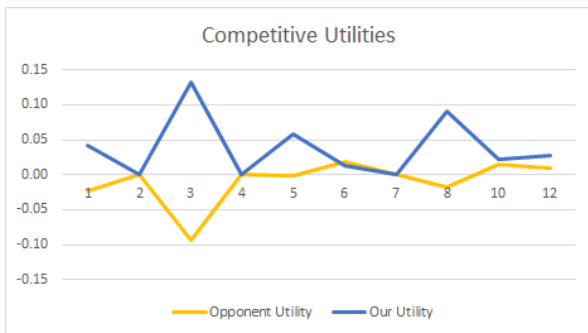


Figure 29: 18 Rounds per Opponent

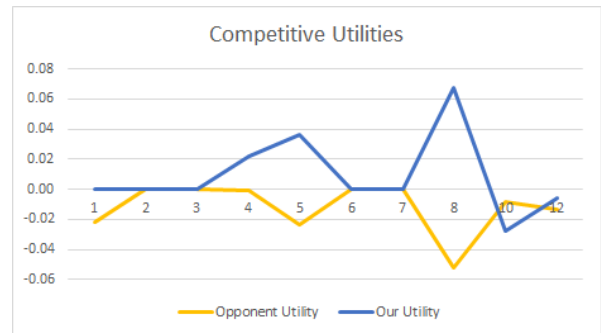


Figure 30: 180 Rounds per Opponent

5 Conclusions and recommendations

After all the tests we have performed, we can conclude that our agent was a bit too tolerant at first, and after tweaking some of the parameters to make it less tolerant, it performed better for itself, and even improved the social welfare a bit.

For future improvements, the changes mentioned in section 3.2 could still be implemented. When it turns out that this agent is good enough to make it to the ANAC, we will certainly do that.

Lastly, we would recommend for the upcoming years to improve the testing experience. We would have liked to define a set of test cases which we could have ran every time we made adjustments to the code. Currently we had to configure and run 60 individual tournament setups, which in total (with 2 computers) took about 40 minutes in total. The reason for these 60 individual setups was that we only wanted to test the specific cases we were interested in (seen that opponent 2 took up to 23 minutes for a single run), and not have to also wait for a test where opponent 2 would take on opponent 4, for example.